THE FEEDING OF FARM ANIMALS

FEEDING FARM ANIMALS

MACEWAN

NELSON

THE FEEDING
OF FARM ANIMALS

Frank Collicutt, Pioneer Cattleman in the Foothills

THE FEEDING OF FARM ANIMALS

By

GRANT MacEWAN

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To
A GREAT, RUGGED, KINDLY CATTLEMAN,
MY FRIEND FRANK COLLICUTT,
AND HIS FELLOW PIONEERS,
THIS BOOK IS RESPECTFULLY DEDICATED

Books by the same author

THE BREEDS OF FARM LIVE-STOCK IN CANADA

In collaboration with A. H. EWEN, M.A., B.Sc.

THE SCIENCE AND PRACTICE OF CANADIAN ANIMAL HUSBANDRY

GENERAL AGRICULTURE

PREFACE

A more general understanding of the nutrition of farm animals is the purpose of this book. It is acknowledged that many of the feeding problems which arise are peculiar to this country, and Canadian stockmen have requested a book which would interpret the science of nutrition and relate it to progressive feeding practices.

Much has been learned about feeds and animal requirements; the energy and protein needed by various classes of live-stock have been determined; the role of minerals has been fairly well established and many of the mysteries of vitamins have been solved. But the value of such information is limited unless it is made available in usable form to those who feed the nation's live-stock and thus direct one of the nation's most important food producing enterprises.

There is a growing appreciation of what can be achieved through proper feeding. Feed will not correct bad breeding; it will not make long legs short and it won't make a cow give 20,000 pounds of milk if her genetic capacity is only 4,000 pounds. But when better feeding is employed along with a programme of better breeding, it can change greatly the appearance and usefulness of farm stock and, indeed, improve the standard of Canadian agriculture.

In securing illustrations for this book, the author has had the co-operative support of many kind friends; special thanks are extended to William Bradley of the *Western Producer*, Miriam Green Ellis of the *Family Herald and Weekly Star*, Colony Farm at Essondale, W. L. Jacobson of P.F.R.A., Regina, secretaries of the breed associations, Ontario Department of Agriculture, Live Stock Branch, and many others.

Special thanks are due to Canada Packers Limited whose whole-hearted co-operation has made the publication of this book possible. At a convention meeting in Winnipeg in January, 1945, the author urged that more attention be given to the nutrition of Canadian live-stock and invited the co-operation of all who were in a position to carry the message of better feeding to rural Canada. At that time the manuscript for the present book was almost completed but with little prospect of publication. Mr. J. S. McLean and other officials of Canada Packers Limited

recognized the need for such a book and immediately promised that their company would sponsor its publication.

Canada Packers Limited, by purchasing the entire first edition for free distribution, have rendered a service to Canadian agriculture. It is the author's hope that "Feeding Farm Animals" will justify this generous assistance and prove useful to farmers throughout Canada.

The Author.

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NUTRITION FOR STOCKMEN

CHAPTER I

THE CHALLENGE OF BETTER NUTRITION

George Washington said that he knew "of no pursuit in which more real and important services can be rendered to any country than by improving its agriculture, its breeds of useful animals and other branches of a husbandman's care."

In the Canadian economy, the production of live-stock and live-stock products is assuming greater and ever greater importance, and promises to be the best link between the welfare of the soils, the security of the farming people and the permanency of agriculture. In addition a better standard of living for the people of all nations demands more foods of animal origin. Even Canada has had too much malnutrition among her people. The success of the live-stock enterprise depends mainly upon markets, breeding policies and the adequacy of feeding methods. The essential nature of markets, domestic and export, is not to be minimized, but Canadians would do well to recognize that nutrition and feeding represent a phase of the stock producer's business which has received rather less than its share of attention.

A good many campaigns have been conducted in the interests of better breeding and the public treasury has supported numerous plans to promote the use of better sires; but much of that effort and money is wasted if the well bred animals are allowed to deteriorate because of inadequate nutrition. It is more and more apparent that breeding policies in Canada are well ahead of feeding practices. One who spends some time at the public stock yards or marketing centres is likely to conclude that inadequate nutrition is responsible for more sub-grade meat animals than poor breeding. That was borne out by at least one organized survey.

Many people who can pour gasoline into a tank and drive an automobile, would be better motorists if they understood something about the gasoline engine. In the same sense there are many live-stock growers who should equip themselves with a better understanding of the principles underlying animal nutrition. They would be able to feed more efficiently and with greater interest if the animal's requirements, the processes of digestion, and the nature of the feeds were understood.

A Fascinating Subject

Indeed, the subject of nutrition is one of the most fascinating phases of modern science and to the live-stock man it can be the most helpful. To be familiar with the mechanics and materials in the nutrition of farm animals is to have a better understanding of human nutrition, because much that is known about the latter was discovered through work with animals. One who accepts the challenge to know more about digestion and nutrition is likely to conclude that in point of fascination and interest, a modern tractor suffers by comparison.

As a matter of fact, the animal body has something in common with a farm engine. Both require fuel in order to operate and

Colony Vrouka Beets Vale, "All Canadian" three-year-old in 1944

both are subject to wear. The animal demands fuel that is more varied in character however; there are well defined requirements for maintenance, repairs, and work or production. Maintenance means keeping the body warm and keeping the heart and other organs in a state of normal physiological operation, and production embodies growth, milk-making, reproduction, fattening, wool production, etc.

Higher Rate of Production Creates New Problems

When the common species of farm animals lived in the wild state, nutrition must have been comparatively simple. With

unrestricted freedom and low rates of growth and production, malnutrition was not likely to occur. Domestication brought restrictions; man placed a fence around his cow, then a roof over her head and chain about her neck, thereby limiting both her range for the feeds of her choosing and her exposure to sunshine. Then, on the often restricted feeds of man's choosing which were placed before the domesticated cow, she was invited to greatly increase her production. Instead of the 1,000 or 2,000 pounds of milk which the undomesticated cow used to give in a year, a self-respecting matron of modern dairy type is expected to produce 10,000 pounds or 20,000 pounds and, if she is to establish a world's record, she must extend herself to something over 40,000 pounds in 365 days. Similarly ton or ton and a half litters of pigs at six months of age and 900 or 1,000-pound steers at one year of age represent new achievements in rate of production.

To increase the burden of production is to increase the need for rations that are adequate in both quantity and kind. The high producer is more vulnerable to malnutrition and it is not surprising that there have been increasing evidences of malnutrition. At the same time there are many potentially great producers among farm live-stock whose production is limited by inadequate rations.

Profitable production from farm animals is dependent upon various factors, not the least of which is economy in rationing. Good rationing to support maximum production would be comparatively simple if economy were not important. The practical hope, therefore, is that by intelligent study, a fair combination of adequacy and economy may be achieved.

Feeding For Thriftiness

There is increasing evidence of a relationship between nutrition and health in man and beast and it becomes the stockman's responsibility, therefore, to employ intelligent feeding as one means of "vaccinating" against a multitude of disorders. Certain feed constituents, such as vitamin A, are now known to have a specific effect in building up a resistance to certain types of disorders, while other feed substances contribute in a more general but none the less effective manner, to body welfare. Prevention of disorder and disease may be fully as important as cure, and much cheaper and more practical. In the same manner, we can look for relationships between nutrition and breeding performance; it may be too much to expect that the addition of some mineral substance or mixture to the ration of a non-breeding bull is going to put everything right, but the fact remains that adequate feeding can influence prolificacy in a manner which the stock owner cannot

Junior Calf Club entries at Kamloops, 1943

afford to overlook. But good nutrition is not achieved merely by purchasing a package of this or a bucket of that; rather it is the result of studiously adapting the ration to the particular requirements of the animal and in most cases, home grown feeds will be adequate. The North American people have gone wild about vitamins; and vitamins are very important for man and beast, but for the most part, the natural way of getting them is through good food or feed rather than pills. (And by the way, it's food if the human eats it and feed when it's for the animal).

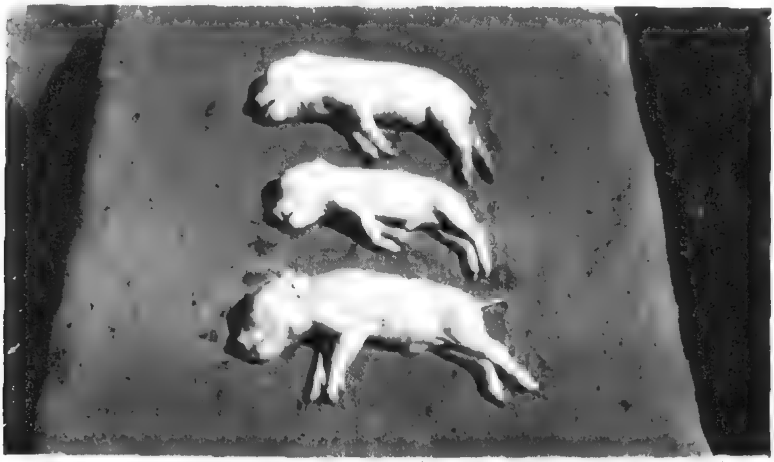
Goitred Lamb. The provision of potassium iodide for the pregnant ewe would have prevented this loss.

Good Rationing

What is meant by good rationing? It means giving the animal, in a reasonably economical way, what it needs to accomplish the task set for it. It is a "double-barreled" requirement and presupposes the provision of a certain bulk and a certain variety or quality. Bulk or quantity is important because, no matter how complete the ration may be in other respects, the stomach and intestines will not function normally without it. Any person who suggests that man or beast will one day subsist on concentrated food in the form of vest-pocket pills, instead of the usual meals, should devote some study to physiology. A certain degree of fullness is essential to the progressive intestinal contractions, described by the high sounding term, "peristalsis", essential to the passage of the intestinal contents along the canal.

Quantity of feed, then, is one requirement; quality is another. It is unquestionably the case in some quarters that animals with

full stomachs are literally starving. There are at least two dozen ways of starving a pig, even a pig with a full stomach, and most of them would apply also to humans. A study of nutritional principles will explain many things about quality requirements in farm animals. Why do young pigs display enthusiasm about rooting in mother earth? Why do goitred lambs occur? Why is legume hay more valuable than timothy hay for many purposes? Why is yellow corn superior to white corn? Why is tankage a better supplement than linseed oil meal for pigs? Why is hay with a green colour better than hay which is bleached? Why is direct sunshine better than sunshine through a window-pane?



Hairless pigs at birth are the result of insufficient iodine in the sow's diet

The author's note-book reminds him that in his meanderings during a single week in the spring of 1941, he saw a cow licking a sweaty horse; an outbreak of tail-chewing in a pen of pigs; a cow chewing bones; several well defined cases of rickets; a Holstein-Friesian cow which the owner said was "burnt-out"; and a litter of hairless pigs. He also saw a sow which had been nursing a litter of ten pigs go down with a fracture in each femur or thigh bone. The study of nutrition will serve to furnish answers for a good many of these questions and problems in animal production, and help to prevent their recurrence. And at the same time it can create a new and tremendously fruitful sphere of interest.

All in all, more thought to feeding practices and the application of what science has discovered about nutrition, would be of great national benefit.

CHAPTER II

"THE NUTRITIONAL BALANCE WHEEL"

The business of raising live-stock is largely a matter of securing a worthwhile return from the feeds used. But the most effective and profitable rationing seems impossible without some knowledge of the component parts of an adequate ration and the functions of each. Balanced rations will have limited meaning unless there is some practical understanding of the basic feed substances to be provided and brought into balance.

A successful engineer must have a thorough knowledge of motors; he must understand for example that the automobile will not operate efficiently and effectively unless there is fuel in the tank, air coming through the carburetor, water in the radiator, oil in the crank case, grease in the transmission, an electric spark when needed and so on. And on top of all he must realize that, the mechanical parts have to be kept in good repair.

The adequate ration is one which provides not only the fuel or energy needed but also those particular materials which have specialized parts to play in construction, repair and physiological functions. In the case of farm animals, carbohydrates and fats are the most common sources of fuel, but proteins are essential for the construction and replacement of muscle tissue; water is necessary for a number of purposes; minerals are needed for structural and other uses and a range of vitamins have intricate yet specific body functions to perform.

Thus the "balance wheel" which symbolizes adequate nutrition is a wheel of many "spokes". Insufficiency of any needed ingredient or incorrect proportion of essential materials will upset the harmony or balance which is necessary to secure the best return in growth or production. Faster growth and greater production have increased the complexity of rationing, increased the need for feed materials and the necessity of balance. It should be the determination of the stockman therefore, to learn all he can about the feed constituents and new discoveries which would change feeding and management practices. The practical aim should be to provide the feeds needed and avoid those which are useless or harmful.

The Common Feeds Have Limitations

The common feeds of the farm are high in carbohydrates; the cereal grains and grass hays are rich sources of fuel or energy or calories. But the same natural feed products are comparatively low in essential protein material and some of the equally essential minerals and vitamins. It will be apparent that for certain types of production, where a lot of protein material becomes part of the product formed, as in milk, those common feeds by themselves are unbalanced and inadequate.

The cereal grains and other feeds rich in carbohydrates have good value for maintenance, the requirements of muscular work and fattening, and yet they do not meet all the body needs.

Herefords on Foothills grass

Where rapid growth and high production of milk are concerned, the common feeds will be particularly inadequate and the challenge to the feeder is to make good the deficiencies and round out the ration with the necessary supplementary materials. In these cases, the needed materials will be protein, supplemental minerals of correct kind and feeds or supplements carrying extra vitamins.

Good and practical rationing requires that additions to the feed will be made in such a manner that the result will mean efficient production and thus profit to the feeder.

The Constituents of a Feed

A brief and practical review of the feed constituents is given here while a more complete description will be found in later chapters. The relationship of the various constituents may be seen from the following in which oat grain is used as an example:

Oats

Water 10.2% Dry Matter 89.8%

Ash 3.2% Organic Matter 86.6%

Crude Protein 13% Fat 4.5% Carbohydrates 69.1% (Vitamins)

Nitrogen Free Extract 58% Fibre 11.1%

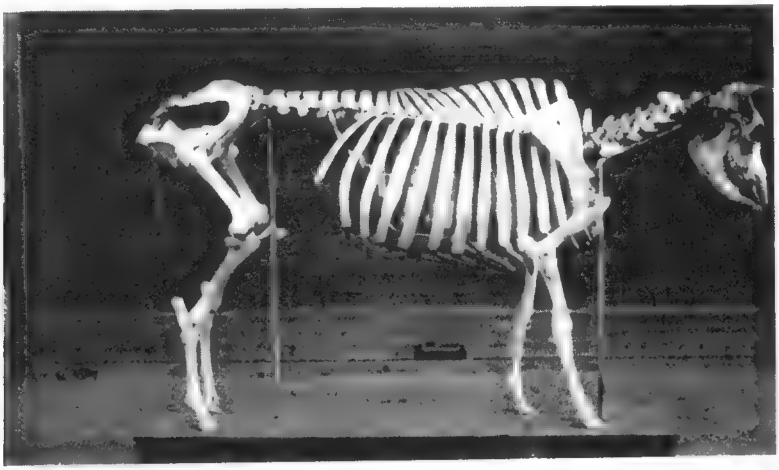
Water. Contrary to some opinions, water is a feed and of exceeding importance. Nothing will contribute more quickly to inefficiency in the use of feed than lack of water or the use of bad water. Water enters into the composition of all body tissues; it aids in transporting digested feed materials; it carries waste matter from the body and helps in equalizing and controlling body temperatures. If not available in sufficient amounts, the work of digestion will be hampered most seriously and digestive disorders like impaction may follow.

The Part that Remains after Burning. There are two important reasons for the feeder being familiar with the animals' need for mineral material. In the first place there are many evidences of reduced efficiency and loss among Canadian live-stock, which can be attributed to lack of some mineral element; and secondly, there are many instances of waste and loss where mineral supplements have been used needlessly or recklessly. Only by an understanding of the materials required for production can the feeder hope to fit the feeds and mineral supplements to the particular needs.

The mineral ash of feed is simply that part which is incombustible; it is the part which remains as an ash after burning. If a 1,000 pound cow were burned completely, about 40 pounds of ash or 4% of her weight would remain as residue. Mineral nutrition is very complicated. The ash of either a feed product or an animal body contains a long list of mineral elements, sodium, chlorine, calcium, phosphorus, iron, iodine, cobalt, magnesium, sulphur, manganese, potassium, copper, zinc, fluorine, boron, bromine, aluminum, and others. But some of these have no special use in the body and some are supplied adequately in the most meagre rations. However, there are still some which

are likely to contribute to deficiency and they should be considered carefully by practical stockmen. The six or seven named first are the ones to which the stockman must give attention.

Mineral elements have a multitude of physiological functions in the body and their purposes are described more fully in a later chapter. All farm animals need salt which is a combination of sodium and chlorine, and nothing will take its place in rationing. Its position should be well understood. After salt, the most wide-spread need is for additional calcium and phosphorus, or iodine or iron. Stating it simply, the most obvious needs in the way of supplements are for extra iron for suckling pigs kept on board or cement floors, iodine for pregnant females, ground



Most of the calcium and phosphorus is in the skeleton

limestone as a carrier of calcium for growing pigs and brood sows, and bone meal or its equivalent for cattle, sheep and colts.

Mixing of mineral supplements is not a necessity, although simple mixtures may be a matter of convenience. It is practical to iodize salt and there may be an advantage at times in mixing bone meal and salt for pasture use, but it should be remembered that the need for mineral supplements is specific and the principle of complicated mixtures is not sound. It is through the provision of the particular mineral supplement or supplements which meet the particular requirement, that the best nutrition and the greatest economy will be achieved.

The Part that Provides Fuel for Heat and Energy. Carbohydrates, fats and proteins are sometimes called the *organic*

constituents of a feed while the mineral matter and water are called *inorganic*. These organic compounds can be oxidized or, in other words, burned to yield heat and energy. Farm animals of all species are warmer than their surroundings and hence fuel is needed to maintain body temperature as well as to furnish energy with which to accomplish physiological and muscular work.

Before the Frenchman, *Antoine Lavoisier*, had the misfortune to lose his head in the French Revolution, he demonstrated that oxygen which forms one-fifth of the air we inhale, is essential to combustion and that burning is merely a matter of oxidation. Now it is known that a gram of sugar or fat when oxidized within the body consumes the same amount of oxygen and yields the same quantity of heat as if it were oxidized or burned in a crucible outside of the body. One of the main differences between burning feeds with a flame and burning them in the animal body is in rate of oxidation. The process is more rapid at the higher temperatures. But what is most important is that all body activity depends upon energy from feeds oxidized or burned within the tissues.

The Most Economical Fuel. The carbohydrate group which includes well-known products such as sugars, starch and fibre, supplies the most economical and most extensively used fuel for the "animal engines" of the farm. Most common rations, even those containing considerable quantities of the cereal straws, furnish sufficient carbohydrate material to provide the heat needed to maintain body temperatures. But the same cereal straws would not furnish a surplus which would support other purposes such as fattening or heavy muscular work; feeds supplying larger amounts of readily available energy would be needed.

Feeds in which the carbohydrate fraction is in the form of the wood-like material called fibre, are not as useful to the animal as are feeds which have a high percentage of the more digestible carbohydrates, starch or sugar. It must seem strange that products like fibre and sugar have such a close chemical link and yield the same amount of energy when oxidized. But the cost of digesting the fibrous material runs away with a good deal of the gross energy in it.

The fact is that farm species do not digest fibre alike. It is a common fallacy that because oats with 30% of hull are good for horses, they must also be good for pigs. The ruminants (cattle and sheep) and horses can digest the fibre in hay and straw and oat hulls with fair success but pigs cannot. Too much fibre is a common weakness in pig rations; furthermore, it is wasteful to give fibrous feeds to animals which cannot utilize

fibre; it can be given to cattle, sheep and horses with comparatively good results.

It is the job of the digestive system to reduce all carbohydrate material to simple sugars so that it can be absorbed by the intestines and used by the body. After the needs for heat and energy are satisfied, a surplus of digested carbohydrates will be converted to body fat.

Fats in feeds are not unlike the fats and oils with which all are familiar,—butter, lard, linseed oil, neats foot oil, etc. They possess certain characteristics in common; they are insoluble in water and soluble in ether or benzine or chloroform.

Like carbohydrates, the fats in feeds are used primarily as a source of fuel for work and heat, but a surplus can be diverted to body fat and thus used as a reserve of energy material. Food fat or body fat burned in or out of the body will yield 2¼ times as much heat as a corresponding weight of starch or sugar and is thus a concentrated source of energy for the animal. The high heat value of fats and oils explains why flax seed is given a Canadian Feed Unit value of 1.48 compared with 1.0 for wheat and 1.11 for corn.

The Protein Part. More than fuel is needed to maintain and operate a house or factory or animal body. Building materials for maintenance, repair and construction are needed and that is where the protein part of a ration has an essential task. The protein compound is built up around nitrogen. There is no common example of pure protein but the dry matter of lean meat or muscle tissue is almost all protein, and casein from milk is protein.

Animal improvement, with an increase in rate of growth and milk production in farm animals, has increased particularly the need for feed protein. No feed constituent demands more of the stockman's attention; and two points stand out, first, that of all the reasons for unbalanced rations, none is so general as insufficient protein and second, the cost of a unit of protein in commercial or supplemental feeds is several times as high as that of a similar amount of carbohydrate material. Consequently, protein material purchased commercially would be a most extravagant source of energy, but for construction of muscle and the making of protein in milk, nothing takes its place. Probably pig producers and dairymen have the biggest problems in providing adequate protein because there the required levels are relatively high.

Proteins are not alike and all proteins do not have the same value in nutrition. The proteins of animal origin, e.g. in meat and milk, are superior to those in vegetable products. Proteins

of vegetable origin such as in legume hay and linseed oil meal, are entirely satisfactory for cattle and sheep because those animals have the power through bacteria in the paunch to rebuild or reconstitute the protein compounds. Pigs cannot do that and must depend on the protein in the ration being adequate. It is on that account that a protein supplement of animal origin or a mixed concentrate containing protein of animal origin is now recommended for pig feeding.

The Practical Problem in Providing Protein

Young grass, legume forages and dairy by-products are the farm feeds which are high in protein and therefore effective in ration balancing. The alternatives would be commercial mill-feeds, meat by-products such as tankage, meat meal and fish meal, and commercially mixed concentrates. The good dairyman knows that rations compounded entirely from cereal grains and non-legume forage will not stimulate or support a high level of milk production, but with legume hay he will not have to buy a lot of high priced meal. The pig grower with a big supply of skim milk or buttermilk need not concern himself much about commercial supplements. But most Canadian farmers are without sufficient legume hay and most pigs coming to market get insufficient milk or other appropriate protein supplement, such as a mixed concentrate containing tankage, meat meal or fish meal, after weaning time.

To feed less protein than is required is to limit production or development; and to provide it beyond optimum amounts is extravagance. In mixing concrete for a piggery floor it would be extravagant to use a higher proportion of cement to gravel than would be necessary to give permanency to the finished floor; at the same time it would be equally extravagant to employ only one part of cement to ten parts of gravel and have the pigs "root out" the floor in a short time. Protein fed in excess of requirements is a costly source of calories or body fat, but in correct amounts it is indispensable to the best use of the entire ration and to body nourishment.

Some Feed Essentials of Late Discovery

The term vitamins embraces an ever lengthening list of important feed constituents. They were only discovered recently and their volume in feeds is so small as to be rather mystifying. But their functions in the body are well defined. Some of them are like the electric spark which fires the combustion engine, inconspicuous but vital to operation.

Fortunately, it is not necessary for the stockman to know all the vitamins by name. Nor does he have to buy vitamins to any

extent since nature has provided them quite generously in natural feeds. Still there are exceptions and he is a wise grower who makes the necessary additions to rations when deficiency threatens.

There is but little evidence of vitamin B deficiency in Canadian live-stock. Pigs on farm rations seem to get about all they need of the B factors from the cereal grains, and the ruminants manufacture their own vitamins of the B family. Vitamin C, the factor which is so necessary for the prevention of scurvy in humans, does not appear as an important factor in feeding farm stock.

Vitamins A and D

Vitamins A and D are the chief worry of the stockman and some knowledge of the parts they play and the best sources, is important. The practical feeder should appreciate the special value of good green pasture on account of vitamins A and D; he should realize the value of a certain amount of direct sunshine as a source of vitamin D. He should also understand the extra goodness of hay with rich green colour on account of vitamin A, that feed factor which promotes growth, prevents certain eye disorders and regulates the functions of delicate membranes such as those lining the respiratory system. A deficiency of such a factor must handicap both body development and health. Tested fish liver oil has become a standard supplement where vitamins A and D are to be supplied.

The discovery of vitamins has placed new emphasis upon variety in rations. Natural feeds of good quality will go a long way toward meeting all needs but there will be times when supplements are needed. The teaspoonful or so of fish liver oil given each day during the winter season to young pigs, calves and colts likely to need additional vitamins A and D should not be regarded as medicine, but as part of good feeding practice in the effort to achieve balance.

The Balanced Ration

A balanced ration is one which provides carbohydrates, fats, protein, water, mineral ash and vitamins in correct amounts so that all requirements are met and there is a complementing effect to ensure the most complete use of feed.

Rations balanced for energy and essential materials will result in better physiological tone in the animal body and produce faster growth, higher production, better health and maximum breeding efficiency.

The Animal Does Not Get Full Value for Feed Eaten

A chemical analysis will show how a feed is constituted and

indicate the amounts of carbohydrates, fats and protein present. But not all of each feed constituent in the ration is digested; a certain portion will be lost in the excreta. Digestion trials which are based upon a comparison of the constituents in the feed and the corresponding constituents in the excreta, show what parts are digested and absorbed and thus made available to the animal. The figures for digestible constituents in a feed or ration would therefore be more useful in estimating values than the figures for analysis.

Knowing the digestibility for the various constituents of a feed, the nutritive ratio (N.R.) can be computed. The nutritive ratio shows the proportion of digestible crude protein to a combination of digestible fat and digestible carbohydrates. A wide nutritive ratio, e.g. 1:22 as in beet molasses, shows the protein material or "flesh forming" part is very low compared with the energy yielding part. A narrow nutritive ratio, e.g. 1:2 as in buttermilk, reveals a relatively high proportion of digestible protein and marks a feed as an effective balancer where more protein is the need. Generally, any ratio greater than 1:6 is considered as "wide".

Net Values For Feeds

But even the figures for digestibility of feeds do not tell the whole story. Stockmen and technical workers have sought to determine the net feeding value of feeds; theoretically the net energy value is determined by making deductions from the gross energy of a feed on account of:

(a) energy lost through undigested portions.
(b) energy lost through urea in the urine.
(c) energy lost as combustible gases from the intestine.
(d) energy cost of mastication, digestion and assimilation.

The net energy represents the amount which can be used by the animal for constructive work or production. The Canadian Feed Unit Values given for feeds described in the chapters to follow are based upon net energy figures worked out as starch equivalents for the different feeds; the unit adopted was one pound of western milling wheat having a starch equivalent value of 73.3. Canadian Feed Unit figures as used extensively in this work or other net energy figures, do not give any special weight to protein and they do not reflect vitamin or mineral content. Consequently their special value is in making comparisons of feeds of similar kind, or in general rationing where due consideration is given to protein, mineral and vitamin requirements of the animals.

PART II

THE COMMON FEEDS, THEIR CHARACTERISTICS AND USES

CHAPTER III

THE GRAINS FOR FEED

The following is offered as a practical classification of feeds:

Concentrates	Grains	Cereal Grains
		Other Grains
	By-products	Grain by-products
		Products of Animal Origin
		Miscellaneous by-products
Roots and Tubers	Roots	
	Tubers	
Roughages	Dry Roughages	Grass hay
		Legume Hay
		Straw
		Emergency roughage
	Succulent Roughages	Grass
		Silage

Most of the figures for composition and nutritive value of feeds, appearing in the following paragraphs are taken from tables in Science and Practice of Canadian Animal Husbandry by MacEwan and Ewen. It may be repeated that the Canadian Feed Unit has been adopted as a measure of net energy value. One pound of Western milling wheat with a starch equivalent of 73.3 was taken as a basis and given a value of 1.0.

THE GRAINS

	Average Composition						Digestible Ingredients in 100 lb.			Total Digestible Nutrients
	Moisture %	Ash %	Fat %	Fibre %	Nitrogen Free Extract %	Crude Protein %	Fat	Carbo-hydrates	Crude Protein	
Oats	10.2	3.2	4.5	11.1	58.0	13.0	3.8	47.5	10.1	66.2
Barley	10.9	2.6	2.0	5.0	67.4	12.1	1.6	64.5	9.1	77.2
Wheat (Milling)	11.1	1.7	2.0	2.4	68.8	14.0	1.3	64.5	10.6	78.0
Corn	11.8	1.5	4.6	2.0	70.4	9.7	4.1	65.5	7.3	82.0
Rye	9.9	2.0	1.7	1.9	72.6	11.9	1.1	67.7	9.9	80.1
Flax	7.9	4.0	35.9	6.1	21.7	24.4	34.1	19.3	19.6	115.6
Buckwheat	12.9	2.2	2.4	10.5	61.5	10.5	1.8	50.0	7.9	62.0
Soybeans	8.1	5.3	18.6	4.5	27.9	35.6	16.8	20.9	31.6	90.3
Peas	9.4	3.0	1.4	5.7	56.9	23.6	0.9	55.3	20.4	77.7
Field Beans	13.3	3.3	2.8	5.7	52.3	22.6	2.2	50.8	17.9	73.7

Oats. Canadian Feed Unit value—0.84
Nutritive ratio—1:5.5
Pounds per bushel—34
Pounds whole oats per gallon—4.25
Pounds of oat chop per gallon—3.0

Oats are the most widely used of Canadian feed grains. Wheat is the only crop which exceeds oats in acreage; 15,407,000 acres of oats were grown in Canada in 1943. They are a universal favourite for horses and the basis of most rations for dairy cattle. They are used extensively for sheep and beef cattle. Commercial feeders of beef cattle want the grain ration to be mostly or all oats at the beginning of the fattening period although heavier and more fattening grains are favoured later. It is on account of the bulkiness of oats and oat chop that the grain is comparatively safe for use by cattle, sheep and horses. The bulkiness is accounted for by the 25% to 30% of hull and 11% fibre.

It should be remembered however, that the same high content of fibre reduces the total digestible nutrients or Canadian Feed Unit value, especially for pigs. Pigs being unable to digest much fibre should not be expected to give the best return from oats. Sifted oat chop, i.e. oat chop with hulls removed, is one of the best grain feeds for suckling or weanling pigs, but ordinary oats with hulls present will retard progress in young pigs and contribute to various disorders. The older pigs seem able to handle oats to somewhat better advantage and the grain is often incorporated in the rations of milking and dry sows.

Oats should be rolled or crushed for horses. Grinding is common practice where cattle and pigs are concerned and for sheep the grain can be fed whole or crushed coarsely.

Wild Oats. Wild oats are noxious weeds and should be controlled. Nevertheless, when quantities of wild oat seed are available, their use as feed must be considered. The value of wild oat grain for feeding will depend largely upon its stage of maturity and plumpness.

The wild oat plants drop their seeds more readily when reaching maturity than do the domestic oats and other cereals, and in order to control these wild oat weeds, farmers will often cut a crop early with the result that the seeds are thin in the kernel and high in fibre. It is possible therefore that a very light sample of wild oats would have little more feeding value than oat hulls. On the other hand, wild oats weighing 34 or 36 pounds per bushel will have about the same feeding value and uses as domestic oats of the same weight. In order to ensure against germination of the wild oats, they should be ground before feeding.

Barley. Canadian Feed Unit Value—1.0
Nutritive Ratio—1:7.5
Pounds per bushel—48
Pounds of whole barley per gallon—6.0
Pounds of barley chop per gallon—4.5

Barley is a standard feed grain in Canada, palatable and fattening. The 1943 acreage was 8,397,000 with most of it grown in the mid-western provinces. It forms the basis of most rations for pigs and fattening cattle. Its low content of fibre makes it more suitable than oats for pigs. The fibre content is 5% compared with 11% in oats. It produces a firm white fat and its use is conducive to a high quality bacon carcass. Barley fed pigs have yielded carcasses possessing a better distribution of fat than those from corn fed pigs, and there has been less over-finish than from wheat fed pigs.

In point of efficiency in making gains in fattening animals, barley is practically on a par with wheat but slightly more bulky and therefore somewhat safer for general use. It will usually represent a more economical source of energy or Feed Units than either oats or wheat, although there have been times when wheat was the cheaper.

As shown by analysis, barley is rich in carbohydrates and comparatively low in protein and mineral matter. It should be used therefore with due regard to the importance of protein and mineral supplements. Some varieties of barley are grown for malting purposes, but in nearly all parts of Canada, the crop is cultivated primarily as a feed crop. It is widely acclaimed for pigs, useful for fattening cattle and lambs, adequate as the grain part of most maintenance rations, suitable in dairy rations when supported by protein-rich feeds and can be used for horses to 50% of the grain feed. Medium grinding is appropriate for most purposes.

Wheat. Canadian Feed Unit Value—1.0
Nutritive Ratio—1:6.4
Pounds per bushel—60
Pounds whole wheat per gallon—7.5
Pounds wheat chop per gallon—6.75

Canadian stockmen were slow to realize the high value of wheat as a feed. Long recognized as a superior grain for milling, it was considered too heavy and dangerous to be a good feed. But quantities of wheat made low in grade by frost or rust, and then years of unsatisfactory markets for all grades, focused attention upon its feeding qualities.

A large programme of experimental work with wheat was

conducted by the University of Saskatchewan between 1930 and 1942 and the studies seemed to establish the following information about the grain as a feed:

(1) Wheat is highly palatable.
(2) It is a concentrated feed which is scarcely as "fool proof" as the lighter grain feeds. Owing to the physical nature of the grain, special care may be required to prevent overfeeding.
(3) Fine grinding is more conducive to pasting and digestive troubles and should be discouraged. Medium and coarse grinding are recommended.
(4) Wheat is at its best as a fattening grain and is practically interchangeable with barley pound for pound.
(5) The lower grades of wheat, e.g. No. 5 N., No. 6 N., and Feed Wheat, contain a higher percentage of bran and lower percentage of flour and are thus somewhat safer to feed. These lower grades for which there is no demand from millers are most practical for feed use.
(6) Wheat has been used as the sole grain for market pigs and when correctly supplemented, the gains have exceeded those from corn or barley. But the quality of the bacon carcasses has sometimes suffered on account of overfinish and it is believed better to feed wheat along with some other grain in the ration.
(7) Steers have finished well and graded choice carcasses where the grain part of the fattening ration was all wheat.
(8) It can be used as a source of energy to some degree in all farm rations when the cost per Feed Unit makes it economically sound.
(9) When properly supplemented or supported by other feeds, wheat can comprise up to 50% or 60% of grain rations for cows, 75% to 90% in case of fattening steers, 75% for pigs, and 50% for horses.
(10) It is important that wheat be fed by weight rather than measure.

Emmer.—Emmer belongs to the wheat family. In the process of threshing, the heads break up into spikelets and retain the chaff. Hence the fibre content is about 10%. Its net feeding value is slightly above that of oats.

Spelt. The seed of spelt resembles emmer and like the latter, it retains its chaff when threshed. It has about the same value as a feed. There is not much interest in growing either emmer or spelt as a feed.

A field of corn for silage

Harvesting corn

Corn. Canadian Feed Unit Value—1.11
Nutritive Ratio—1:10.2
Pounds per bushel—56.
Pounds whole corn per gallon—7.0
Pounds corn meal per gallon—6.25

Corn is the great national feed crop of United States and imported or home grown corn is sometimes available in Canada. As indicated by the Feed Unit figure, it is rich in net energy and is at its best for fattening.

Its relatively high content of oil, 4.6%, makes corn a particularly palatable feed but also reduces keeping qualities. If storage conditions are not favourable, corn meal will develop rancidity and become unpalatable and unsatisfactory for feeding.

Yellow corn contains worthwhile amounts of carotene, precursor of vitamin A.

The work of Dr. Crampton demonstrated the unfavourable effect upon bacon carcasses when market pigs received heavy allowances of corn. Fat deposit was affected adversely, with poor distribution and a tendency to softness. The conclusion was drawn that rations for market pigs should not contain a high percentage of corn. Corn is better suited to fattening steers and lambs and can be used to furnish part of the energy material needed by milking cows. Like wheat and barley, corn is rich in calories but low in protein and mineral matter and should be fed in conjunction with selected feeds. For general use in fattening practice, sound corn is worth roughly the same price per pound as wheat and barley.

It is quite common practice to feed corn in the unground form in United States; pigs are allowed to follow cattle in the feed-lot for the purpose of recovering grain which escapes mastication and digestion by the cattle. In Canada, however, grinding is favoured.

Rye. Canadian Feed Unit Value—1.03
Nutritive Ratio—1:7.1
Pounds per bushel—56
Pounds of whole rye per gallon—7.0
Pounds of rye chop per gallon—6.25

In point of fibre content, carbohydrates, protein, and mineral matter, rye resembles wheat, but rye is criticized severely by feeders because of its unpalatability. The result is that rye is unpopular as a feed, but it is often the cheapest source of energy on the feed grain market. Stockmen report that digestive disorders are more prevalent when rye is fed.

In spite of objections, however, rye can be used successfully

when it is combined with other and more attractive grains; oats and barley are often used in conjunction with rye. In any case, the rye will be most useful when it comprises not more than 30% or 40% of the total grain. Fed to milking cows, rye will produce a hard butterfat.

Feeders should not forget that ergot which occurs quite often in rye, is capable of producing abortion and serious illness. When ergot is found to be present in the grain, steps should be taken to remove it by means of a cleaning mill or salt brine solution. The only alternative would be to reduce greatly the proportion of rye in the grain mixture and thus reduce the concentration of the plant fungus.

Flax. Feed Unit Value—1.48
Nutritive Ratio—1:4.9
Pounds per bushel—56
Pounds of whole flax per gallon—7.0

Flax is grown mainly for oil extraction; its by-product, linseed oil meal, is more important as a feed than is the parent seed. The oil content of flax will be noted as about 36% and market price will usually limit use of the whole grain in feeding. The oil is used in the manufacture of paints, varnishes, linoleum, oil cloth and patent leathers. Apart altogether from price, the high oil content would reduce the safety and practicability of the feed, except in small amounts.

Ground flax is an important ingredient in many calf meals or skim milk supplements for calves. To ensure a certain moderate level of fat in rations of milking cows, a little ground flaxseed is appropriate and small amounts in some other rations will prove healthful. But as a source of protein for balancing purposes, the by-product, linseed oil meal, will be more effective and more economical. Apart from small allowances in various rations, flax has but limited importance in general feeding practice and will not take the place of linseed oil meal. Flaxseed meal is simply ground flax and should not be confused with linseed oil meal.

Immature or stunted or damaged flaxseed represents a possible source of danger in feeding. Prussic acid poisoning may result from its use with resultant sudden death. Where the hazard is suspected, boiling the seed will destroy the enzyme which activates the poison principle and thus render the flax safe to use.

Buckwheat. Feed Unit Value—0.78
Nutritive Ratio—1:6.8
Pounds per bushel—48
Pounds of buckwheat per gallon—6.0

Of the 286,000 acres of buckwheat grown in Canada in 1943, most of it was in Ontario and Quebec. Buckwheat seed contains a fibrous hull and has almost as much total fibre as oats. The net feeding value is reduced, especially for pigs. Furthermore, a high intake of buckwheat may produce soft pork. It is grown as an emergency crop where some other crop has failed in some parts of Canada, but it has never taken a place among essential feeds. It can be worked into general rations up to 30% or 40% along with such grains as barley, corn and wheat but the net value is lower than oats and palatability is not so high. Buckwheat should be ground for feeding to farm animals. Some animals, usually white ones or those having white on them, may be found to possess an intolerance to buckwheat with the result that skin eruptions and itching will occur.

Soybeans. Feed Unit Value—1.15
Nutritive Ratio—1:1.9
Pounds per bushel—60
Pounds of soybeans per gallon—7.5

Soybeans represent one of the richest of grain feed products. They carry less fibre than barley and nearly as much protein as linseed oil meal. Coupled with that, the fat content is around 18% to 20%. Not only is the protein content higher than in any other grain used for feeding, but the quality of the protein is higher than in cereal or other legume seeds. Consequently, soybeans and their by-products have high value for balancing rations. For dairy cattle, they are considered equal to cottonseed meal for balancing but not as palatable and stimulating as linseed oil meal. In the case of pigs, unfortunately, soybeans will produce soft carcasses and should not be fed in large amounts. When fed to pigs, if the beans are cooked they are more digestable, but it is important to remember that owing to the high content of oil, the ground soybeans are likely to become rancid.

Field Peas. Feed Unit Value—1.02
Nutritive Ratio—1:2.8
Pounds per bushel—60
Pounds of field peas per gallon—7.5

The seed of field peas has high feeding value, running to more than 23% of crude protein. But yields of threshed grain are not high and the crop is not widely grown for feed. Where the grain is available at a reasonable price, however, it can be used for cattle, sheep and pigs to good advantage. It is palatable and is in the highest favour with sheep men. At one time, pea-fed bacon was considered a superior product but today, peas are not

often fed except in grain mixtures supplemented with some protein of animal origin. The quality of protein is not particularly high and is thus more acceptable for cattle, sheep and grazing pigs than for dry-fed pigs.

Field Beans. Feed Unit Value—0.96
Nutritive Ratio—1:3.1
Pounds per bushel—60
Pounds of field beans per gallon—7.5

Field beans resemble field peas in analysis but owing to lower palatability, lower digestibility and lower quality of protein, the feeding value is definitely less. For pigs, beans should be cooked and fed with cereal grains.

A winning pen of fat cattle

Grain Millet. There is some interest in millet as a grain crop. It is valuable in wet seasons when it can be seeded as late as the end of June. New varieties produce well, giving a yield of grain which compares favourably with cereal grains. The seed contains about 8% to 9% of fibre and 12% of crude protein. Experiments at the Central Experimental Farm, showed that "millet grain or seed in combination with other grains and a protein-mineral supplement can comprise 25% to 50% of the grain for hogs very satisfactorily".

To Determine Quantity of Grain in a Bin. A measured bushel requires approximately $1\frac{1}{4}$ cubic feet of space. To determine the number of bushels in a bin therefore, find the contents in cubic feet, multiply by four and divide by five. To estimate the bushelage by weight it would be necessary to know the exact weight of one bushel. A bin measuring 10 feet long, 10 feet wide and 10 feet high and filled with barley may be taken as an example. The contents would be 1,000 cubic feet and the bushelage by measure would be 800, ascertained as follows:

$$\begin{array}{r} 1{,}000 \\ 4 \\ \hline 4{,}000 \end{array} \div 5 = 800 \text{ measured bushels.}$$

But if, for example, the barley in question weighs 50 pounds per measured bushel instead of the standard 48 pounds, then the bushels by weight in this bin would be $800 \times \frac{50}{48} = 833$ bushels.

CHAPTER IV

VEGETABLE BY-PRODUCTS

Oat Groats. Canadian Feed Unit Value—1.06
Nutritive Ratio—1:5.2

Oat groats are the oats after the hulls have been removed and are sometimes available for feeding purposes. Varieties of hulless oats will give a feed product of the same value. Wild oat groats are from wild oats and have approximately the same feeding value as the groats from domestic oats.

The fibre content is low and the palatability high. Oat groats have their greatest value for young pigs; the ground groats plus a suitable protein supplement will make an excellent "starter" ration for weanling pigs. This feed would be especially useful for those young pigs which have been weaned before the age of seven weeks. Oat groats would have wide use in rations for all classes of farm stock but costs usually restrict their use.

Oat Feed. Canadian Feed Unit Value—0.5
Nutritive Ratio—1:10.8

In the milling of oats to produce rolled oats or oat meal, the by-products are oat hulls, oat shorts and oat middlings. A mixture of these containing not more than 22% of fibre is called oat feed. With the fibre content approaching that maximum, oat feed may be regarded more or less as an intermediate between grains and roughages. Its greatest use will be in mixtures with low-fibre grains, like wheat, for feeding to horses and cattle. The net feeding value is in line with that of good roughages.

In the case of oat shorts, the fibre content must not exceed 7% and with oat middlings, not over 4%.

Oat Hulls. Canadian Feed Unit Value—0.47
Nutritive Ratio—1:18.2
Pounds per gallon—1.25

Oat hulls are the fibrous outer coverings removed from oats in the milling process and might be classified as a roughage rather than a grain. Any combination of oat shorts, oat middlings and hulls, having a fibre content exceeding 22%, must be

VEGETABLE BY-PRODUCTS

	Average Composition						Digestible Ingredients in 100 lb.			Total Digestible Nutrients
	Moisture %	Ash %	Fat %	Fibre, %	Nitrogen Free Extract %	Crude Protein %	Fat	Carbo-hydrates	Crude Protein	
Oat Groats	9.0	2.2	5.9	2.2	64.2	16.5	4.6	60.0	14.1	84.4
Oat Feed	8.4	5.3	2.6	21.0	56.7	6.0	1.9	41.0	4.2	49.5
Oat Hulls	5.9	5.3	2.1	30.5	51.8	4.4	1.6	40.0	2.4	46.0
Brewers' Dried Grain	8.5	3.8	5.3	13.8	46.8	21.8	4.6	34.7	15.5	60.1
Malt Sprouts	7.5	6.0	1.7	13.2	45.6	26.0	1.5	47.9	20.0	71.3
Distillers' Dried Grains	7.0	2.7	8.7	13.4	42.4	25.8	7.7	32.7	18.3	68.3
Wheat Bran	10.6	5.6	4.5	10.5	52.7	16.1	3.1	39.8	12.0	58.8
Wheat Shorts	10.4	4.1	5.2	7.1	56.2	17.0	4.5	47.8	12.4	70.3
Wheat Middlings	10.5	3.6	4.9	4.3	59.3	17.4	4.3	50.7	12.9	73.3
Feed Flour	10.5	2.1	3.3	2.0	64.6	17.5	2.8	57.6	15.4	79.3
Recleaned Screenings	11.5	3.0	3.8	6.1	61.6	14.0	3.3	46.9	10.1	64.4
Corn Gluten Meal	9.6	1.1	4.2	2.1	46.5	36.5	3.9	42.9	31.5	83.2
Corn Gluten Feed	8.6	1.9	3.2	6.3	54.1	25.9	2.5	51.5	22.0	79.1
Hominy Feed	9.2	2.6	7.7	4.7	65.1	10.7	7.0	62.2	7.1	85.1
Linseed Oil Meal (OP)	9.1	5.2	7.7	8.1	34.7	35.2	7.1	31.8	30.3	78.1
Linseed Oil Meal (NP)	9.4	5.5	3.2	8.8	36.4	36.7	2.9	33.6	31.7	71.8
Cottonseed Oil Meal	7.7	6.3	8.1	10.0	28.5	39.4	7.7	21.9	34.0	73.2
Soybean Oil Meal	9.0	5.5	5.8	5.9	32.3	43.5	5.0	34.0	37.0	82.3
Dried Beet Pulp	8.4	3.3	0.6	19.0	59.8	8.0	0.5	71.6	5.3	78.0
Beet Molasses	25.0	6.7			61.3	7.0		55.0	2.4	57.4
Cane Molasses	25.7	6.1			64.4	3.8		57.9	1.3	59.2

designated "oat hulls". Oat hulls as sold will often carry up to 30% or more of fibre and the net feeding value places the feed in the same general category as grass hay.

This product has practically no place in pig feeding but has been used successfully for cattle, sheep and horses. Oat hulls will effectively give bulk and lightness to grain rations which would otherwise be too heavy. Only a small amount should be used in rations for dairy cows, but larger amounts could be fed to beef cattle and sheep. Wintering brood cows have been fed oat hulls to replace up to 40% of the roughage, although such a high percentage sometimes causes scouring. For cattle and sheep, the oat hulls are likely to find their greatest use in maintenance rations.

The best results with oat hulls have been obtained by the horsemen who have used the feed in various ways;

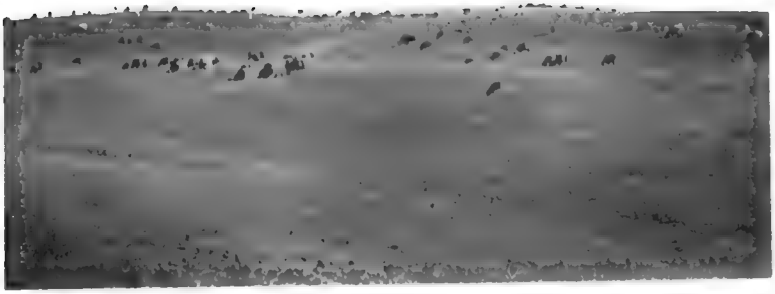
(a) as a partial substitute for hay in rations of working horses.
(b) as part of a mixture with cracked wheat to substitute for oats. (One part by weight of oat hulls and three parts of cracked wheat).
(c) as a prominent part of the ration of wintering idle horses.
(d) as a feed for use from self feeders in fattening horses for sale.

It is when the market price of oat hulls is no higher than that of grass hay, that the widest use will be made of the feed in rations for horses, beef cattle and sheep.

Brewers' Dried Grains. Canadian Feed Unit Value—0.68
Nutritive Ratio—1:3.0
Pounds per gallon—2.5

In the manufacture of beer, barley of selected kind is steeped in warm water for two or three days or until it begins to sprout. *Diastase*, the enzyme which changes starch to sugar is thus increased and then the grain is dried and the sprouts removed. The grain is now called "malt" and the sprouts are "malt sprouts". The next step consists of grinding the malt and adding water to make a mash. With favourable temperature, more starch changes to sugar and this is extracted to be boiled with hops, cooled and fermented with yeast.

The mash which remains after extraction is the brewers' wet grain which carries 70% or 75% of water and is either taken away for feeding in the wet state or dried to be sold as brewers' dried grains. The use of the wet grains is usually restricted to areas close to the brewery on account of the poor shipping and



Sheep on a western range

Mares and foals on pasture

keeping qualities of this product. It is used most extensively by dairymen who feed from 20 to 25 pounds of it per day per cow. Approximately 4 pounds of the wet grains will replace one pound of mixed grain for milking cows. Because of the quickness with which the wet mash sours, dairymen using it must exercise the greatest care to keep mangers clean. It is quite palatable and slightly laxative.

The brewers' dried grains have the same characteristics as the wet grains, except for water content which is brought down to less than 10%. With much of the carbohydrate material removed from the grain, the protein content is considerably higher than in the original barley and hence the brewers' grains have good balancing value in cattle rations. The brewers' dried grains will have above 20% of crude protein compared with 12% in barley. The dried grains like the wet grains are used mainly for dairy cattle where they are incorporated in mixtures. If the price warrants, these dried grains can be used in rations for beef cattle, sheep and horses but with a 14% fibre content, they will not find much use in pig feeding. These dried grains possess just medium palatability.

Malt Sprouts. Canadian Feed Unit Value—0.81
Nutritive Ratio—1:2.6
Pounds per gallon—2.5

As indicated by the nutritive ratio, malt sprouts are high in protein although the protein is not of particularly good quality. Because of low palatability, the product is most commonly sold in mixtures. Sometimes it is mixed with the brewers' dried grains before leaving the brewery. Its main use is in dairy rations where it may represent an economical source of protein. It is not often fed at more than 1½ or 2 pounds per cow; it must be fed along with more palatable grains.

Distillers' Dried Grains. Canadian Feed Unit Value—0.76
Nutritive Ratio—1:2.7
Pounds per gallon—2.5

Distillers' dried grains are the by-product when alcohol and distilled liquors are made from the cereal grains, mainly rye, barley, corn and wheat. In composition, this feed resembles brewers' dried grains closely, having 25% to 30% of crude protein. It is used principally in dairy rations. It, too, is somewhat lacking in palatability and its high fibre content precludes more than slight use in pig feeding. Where it represents an economical source of Feed Units and protein, it might be used to advantage in rations of fattening steers and lambs. In any case it is better to use it in small amounts with palatable feed.

Wheat Bran. Canadian Feed Unit Value—0.6
Nutritive Ratio—1:3.7
Pounds per gallon—2.25

In the making of flour from wheat, the grain is cleaned, moistened to toughen the outer coats and then crushed by a series of steel rollers. As crushing progresses, the product is divided by means of sieves into five or six fractions or "streams" ranging from coarse to fine; some of those streams are returned to the roller. An attempt is made to recover most of the *endosperm* or starchy portion in granular form called "purified middlings", in which form the most complete separation from the offal is possible. In high grade milling, 65% to 75% of the wheat will be recovered as flour.

The outer coats of the wheat kernel constitute the bran. The floury portion is in the central part of the kernel while most of the fibre, protein and mineral matter will be in the outer layers, including the aleurone layer.

With 10½% of fibre, bran hasn't much place in feeding pigs but it is a favourite with dairymen because of its bulkiness, palatability and laxative qualities. Most rations for milking cows and other lactating females will benefit by the addition of some bran. Many dairymen feed 20% of bran regularly. Seventy-five per cent oats and twenty-five per cent bran is an excellent combination for brood mares, growing colts, calves, milking ewes, breeding bulls, and rams. Bran is an appropriate feed to be used for working horses on idle days, and for saddle horses which are used irregularly a mixture of equal parts of bran and rolled oats is suitable.

Bran carries most of the phosphorus in the wheat and excessive feeding could result in an imbalance of the bone building minerals and perhaps bran disease. But bran disease is rarely encountered and many rations would be improved by additions of bran. Price in relation to net feeding value or Feed Units will appear high but palatability and healthful tendencies will help as a counterbalance.

According to the Canadian Feeding Stuffs Act, bran must not contain over 11.5% of crude fibre.

Wheat Shorts. Canadian Feed Unit Value—0.81
Nutritive Ratio—1:4.7
Pounds per gallon—3

This too is a by-product from the milling of wheat flour. It consists of "fine particles of bran, germ, and a small proportion of low grade or fibrous flour as separated in the usual processes of flour milling". It is higher in protein than the original wheat

but not so fibrous and bulky as the bran. It is essentially a pig feed and is used in mixtures for weanling pigs and nursing sows. If at any time shorts represented a cheaper source of feed units than barley or other common feed grain, it could be used widely in pig rations, and to some degree in rations for fattening cattle and milking cows. Shorts should not contain above 8% of fibre.

Wheat Middlings. Canadian Feed Unit Value—0.95
Nutritive Ratio—1:4.7
Pounds per gallon—3.25

Middlings is finer than shorts; it contains less of the bran and germ and more of the low grade flour. Like shorts, the middlings is medium rich in protein but is rated a better feed for young pigs. With middlings, the upper limit for fibre is set at 4.5% compared with 8% for shorts and 11.5% for bran.

Feed Flour. Canadian Feed Unit Value—1.04
Nutritive Ratio—1:4.2

Feed flour or "red dog flour" is a little finer in texture than wheat middlings but has about the same feeding value as the better grades of the latter. Fibre content is lower than that of wheat. It is essentially a pig feed but is too fine and pasty to be fed alone. When feed flour can be purchased at a price which will yield feed units as cheaply as coarse grains, 50% of pig rations may consist of it and the balance be made up of barley or oats and barley.

Recleaned Screenings. Canadian Feed Unit Value—0.78
Nutritive Ratio—1:5.4

The quality and value of screenings as a feed vary widely and depend on the material comprising it. Standard recleaned screenings (No. 1 Feed Screenings) consist of broken and shrunken grains, chiefly wheat, wild buckwheat, wild oats, and not above 3% chaff and dust. The good samples of recleaned screenings will carry not more than 7% fibre and a minimum of small black seeds like mustard and french weed. Recleaned screenings of lower grade may carry up to 11% fibre and contain somewhat more chaff, small black seeds and dirt.

The practicability of using recleaned screenings will depend very largely upon price in relation to other feeds. Good samples are suitable as a partial substitute for barley or wheat in rationing pigs, sheep and cattle, and should be worth 80% of the price of barley. Because of the weed seeds, recleaned screenings should be ground more finely than common grains.

Refuse screenings are mostly chaff, light seeds and grain dust.

Feed of this quality runs high in fibre and should be classified as roughage rather than grain. It is used more by sheep men and feed-lot operators.

Corn Gluten Meal. Canadian Feed Unit Value—1.10
Nutritive Ratio—1:1.6
Pounds per gallon—6.75

Corn gluten meal is that part of shelled corn which remains after the separation of the larger part of the starch, germ and bran, in the course of manufacture of cornstarch and glucose. It contains a lot of protein, 36%, and is therefore very valuable in correcting low protein mixtures. Its chief use is in dairy rations where it has about the same function as linseed oil meal.

Corn Gluten Feed. Canadian Feed Unit Value—1.06
Nutritive Ratio—1:2.6
Pounds per gallon—5.25

In the manufacture of cornstarch and glucose from corn, the by-products described as gluten meal and corn bran may be united while still moist to form gluten feed. The gluten feed carries 25% of protein compared with 36% in the gluten meal and it too finds its major use in dairy rations. Gluten feed is in wider use than the gluten meal. It is palatable and reasonably bulky.

Hominy Feed. Canadian Feed Unit Value—1.08
Nutritive Ratio—1:11.0
Pounds per gallon—4.5

Hominy feed results from the manufacture of hominy, hominy grits and corn meal. It includes the corn bran, germ, part of the starch and some of the oil. It contains not less than 5% of crude fat. In general characteristics for feeding, it is very much like corn grain, although the hominy feed is slightly higher in protein and fat. It can replace barley or wheat in fattening rations for cattle and lambs, but much of it in pig rations would likely result in soft carcasses.

Linseed Oil Meal. Old Process Meal—Canadian Feed Unit—0.99
Nutritive Ratio—1:1.6
New Process Meal—Canadian Feed Unit Value—0.91
Nutritive Ratio—1:1.3
Pounds of linseed meal per gallon—4.5

Linseed oil from flaxseed has high commercial value and after its removal from the seed, the residue, linseed oil cake or oil meal,

is a superior feed for live-stock. Three methods are employed to extract the oil, hydraulic and expeller methods known as "old process", and the solvent method called "new process". By the "old process" methods which yield an oil meal of the highest feeding value, the flaxseed is ground, heated and exposed to mechanical pressure to extract the oil. The "new process", involving the use of a solvent, results in more complete oil extraction and hence a less nutritious by-product remains.

A certain amount of oil or fat is beneficial to farm animals.

Grand champion steer at the International Fat Stock Show at Chicago, 1929, sold for $8.25 per pound.

Milking cows should receive 4% of oil or fat in their concentrate ration and furthermore, the "old process" meal seems superior for conditioning purposes.

The hydraulic method of extraction leaves the by-product in the form of flat, cylindrical cakes; hence the name linseed oil cake. When these cakes are broken, the product is called "nutted linseed oil cake", and when ground, it becomes linseed oil meal.

Actually, linseed oil meal made by either process is an exceptionally valuable live-stock feed. It is superior because of the high protein content, about 36%. It is the protein supplement most widely used for dairy cattle in Canada. Its position in

dairy rations will depend somewhat upon the extent to which legume roughages are used; without alfalfa or clover hay more linseed oil meal or similar supplement is needed in the ration.

Linseed oil meal is also favoured as a supplement for show cattle, fattening steers, lactating mares and ewes, and as a component of concentrate mixtures. It will frequently constitute from 15% to 30% of protein-mineral concentrates for pigs, along with tankage, fish meal and alfalfa meal. With high protein, palatability and laxative qualities, linseed oil meal is a contribution to safety in general feeding. The price is often high in relation to Feed Units and protein but a certain moderate amount represents good economy in many rations.

Cottonseed Oil Meal. Canadian Feed Unit Value—0.93
Nutritive Ratio—1:1.2
Pounds per gallon—6.0

Cottonseed cake or meal is the residue following the extraction of oil from cotton seed. It is composed mainly of the kernel but there is a portion of the hull remaining with the result that fibre content is close to 10%. Protein in cottonseed meal is 36% or better, and in the United States it is one of the most commonly used high-protein supplements for dairy cattle. On markets where it is sold regularly, it usually offers protein at lower cost per unit than would be the case with linseed oil meal or corn gluten meal.

But cottonseed meal lacks the palatability and healthful qualities of linseed oil meal and it is known to be deficient in lime and vitamin A. A poison substance called "*gossypol*" will do injury if the meal is fed excessively. Some forms of disorder in cattle which have been attributed to gossypol, have probably been due to calcium deficiency or vitamin A deficiency, because the so-called "cottonseed injury" has not occurred when good alfalfa hay has been fed in the ration. It is not suitable for pig feeding but cows may be given up to 2 to 3 pounds a day and ewes, one quarter of a pound.

There are several grades of cottonseed meal; the best product is bright yellow in colour. Dark colouration may indicate overheating, the addition of hulls or some fermentation.

Cottonseed feed is a mixture of cottonseed meal and ground cottonseed hulls. It will commonly carry 50% more fibre and 20% less protein.

Soybean Oil Meal. Canadian Feed Unit Value—1.05
Nutritive Ratio—1:1.2

Soybean oil meal remains after most of the oil has been extracted from soybeans. It is higher in protein than either linseed

oil meal or cottonseed meal and the quality of protein is likewise superior. Here is a feed which is enjoying increasing popularity with stockmen; it is palatable and slightly laxative, and can be used in roughly the same manner as linseed oil meal. Dairymen might incorporate up to 15% or more of it in grain rations for milking cows; small amounts could be worked into the rations of young and growing cattle or lambs, and pig feeders can use it to good advantage in protein-mineral concentrates fed as substitutes for skim milk. On account of the higher quality of the protein, this is the most valuable of the common oil meals for use in pig rationing.

Cocoanut Oil Meal. Cocoanut oil meal, also called *copra oil meal* is the ground residue after extraction of oil from the dried meat of the cocoanut. It is palatable and useful when price is favourable. Its protein content is not as high as that of the oil meals mentioned previously but is about 25% above the protein content of bran. Oil content will be 8% to 10% and keeping qualities are not good. Its main use is in dairy rations, but small amounts could be worked into various rations for cattle, horses, sheep and pigs.

Peanut Oil Meal. This feed is rarely encountered in Canadian feeding practice. It is the residual product after the extraction of the oil from the peanut. Meal from hulled peanuts will carry more than 40% of protein and from 8% to 10% of oil; owing to the oil content the meal is liable to become rancid in warm weather. It is a good supplement for dairy cattle, beef cattle and sheep. More than very moderate amounts fed to market pigs produce soft carcasses.

Dried Beet Pulp. Canadian Feed Unit Value—0.92
Nutritive Ratio—1:13.7

The Feeding Stuffs Act describes dried beet pulp as "the dried residue from sugar beets which have been cleaned and freed from crowns, leaves and dirt, and from which sugar has been extracted."

The wet pulp from which the dried product comes contains between 85% and 90% of water and thus is not suitable for transportation or keeping. It must be used in areas near beet sugar factories and its value is considered to be about equal to corn silage on the basis of dry matter. It is extensively fed to fattening steers and lambs and sometimes to milking cows; it is at its best when fed with legume hay. Both the wet and dried products are low in protein and low in phosphorus.

For best results in using the dried beet pulp, allow it to soak up two or three times its own weight of water; then it will be a

A pen of selected crossbred feeder calves

Courtesy Ontario Live Stock Branch

First prize carlot market lambs—Delaware Sheep Club, Boy's and Girl's Exhibitors, Middlesex County, C.N.E. 1931.

satisfactory substitute for silage or roots. It is bulky, palatable and mildly laxative,—an all-in-all satisfactory source of succulence for use by herdsmen on the exhibition circuit. Its price however, is usually higher than that of home-grown silage. Cows may be given from 5 to 10 pounds of the dried product daily, and for sheep and lambs from one half to one pound a day is a reasonable allowance. There is no practical place in horse or pig rations for dried beet pulp.

Beet Molasses. Canadian Feed Unit Value—0.68
Nutritive Ratio—1:22.9
Pounds per gallon—12.0

Beet molasses is a by-product of beet sugar manufacture. It is palatable, is a rich source of readily available carbohydrates and adds to the attractiveness of otherwise plain rations. It is quite laxative and should not be fed in large amounts. While molasses is an appetizer often used along with mediocre or unattractive feeds, there are two major criticisms; first, it is low in protein, and secondly, its cost per feed unit usually makes it a more expensive source of energy than common farm feeds. Tests have shown that beet molasses has about the same potential value for cattle as mixed grain, pound for pound.

Sheepmen refuse to feed molasses because of the danger of contaminating the wool and it is seldom used for pigs or horses. It is essentially a cattle feed and up to two or three pounds a day can be fed to steers or cows. When molasses is used to improve the palatability of roughage feeds, dilute it with an equal quantity of warm water and sprinkle the liquid over the rough feed.

Cane Molasses. Canadian Feed Unit Value—0.70
Nutritive Ratio—1:44.5
Pounds per gallon—12.0

Cane molasses, a by-product from the manufacture of cane sugar, enjoys a better reputation with stock feeders than beet molasses. It is more mildly laxative and has greater palatability Like beet molasses, however, its main value is in improving the attractiveness of plain rations. It, too, is extremely low in protein and has nothing to offer in improving protein balance; this is indicated by the very wide nutritive ratio.

An allowance of cane molasses is considered a safeguard against impaction in cattle and it should help to prevent some forms of colic in horses. If it were not for the price factor, cane molasses would be fed extensively to cattle and horses. The best method of feeding consists of diluting with warm water and sprinkling over dry roughage.

CHAPTER V

FEED PRODUCTS OF ANIMAL ORIGIN

This group of important feeds is composed of:
(a) Dairy products and by-products.
(b) Packing house by-products.
(c) Fishery by-products.

Cows' Milk, Whole. Canadian Feed Unit Value—0.22
Nutritive Ratio—1:4.0

Whole milk from normal and healthy dams is the best feed known for young animals. Where young animals run with their mothers and nurse in a natural manner, they get the milk warm and clean in optimum amounts. Under those circumstances, digestibility is very high and the daily gain of a calf receiving whole milk and nothing else often exceeds the weight of the dry matter present in the milk. Owing to the high value of cows' milk for human consumption, milk drawn by hand or machine is rarely used for animal feeding except in the case of very young calves which are to be raised by hand feeding methods.

The milk of one species may differ quite a lot from that of another and there is some variation within a species. Cows' milk varies in content of butterfat but only a little in other constituents. The fact is not to be overlooked that cows' milk is an exceedingly well balanced feed, well supplied with carbohydrates, fats and proteins,—all of which are readily digested,—and calcium, phosphorus, and the B vitamins; vitamin A is high in milk from cows on good rations. Only in iron and vitamins C and D is cows' milk conspicuously low.

The analysis of the whole milk of some common species is shown:

	Water %	*Ash %*	*Fat %*	*Sugar %*	*Crude Protein %*
Cow's Milk	87.2	0.7	3.8	4.8	3.5
Mare's Milk	90.7	0.4	1.2	5.7	2.0
Ewe's Milk	81.2	0.8	6.8	4.8	6.4
Sow's Milk	84.3	1.0	4.7	3.3	6.7
Goat's Milk	86.7	0.8	4.3	4.4	3.8

Skim Milk. Canadian Feed Unit Value—0.12
Nutritive Ratio—1:1.8

FEED PRODUCTS OF ANIMAL ORIGIN

	Average Composition						Digestible Ingredients in 100 lb.			Total Digestible Nutrients
	Moisture %	Ash %	Fat %	Fibre %	Nitrogen Free Extract %	Crude Protein %	Fat	Carbo-hydrates	Crude Protein	
Cow's Milk	87.2	0.7	3.8		4.8	3.5	3.8	4.8	3.3	16.7
Skim Milk	90.4	0.7	0.3	..	5.1	3.5	0.3	5.1	3.3	9.1
Buttermilk	91.3	0.7	0.3	.	4.5	3.2	0.7	4.5	3.0	9.1
Whey	93.6	0.5	0.2		4.9	0.8	0.2	4.9	0.7	6.1
Tankage (High Protein)	8.8	19.0	9.3	2.5	1.9	58.5	8.8	. .	54.4	74.2
Tankage (Low Protein)	7.7	22.2	15.2	3.2	5.8	49.9	14.4	. .	42.7	75.1
Meat Meal	9.8	20.9	10.3	1.9	1.8	55.3	9.8	.	51.5	73.6
Blood Meal	13.2	3.8	1.1	.	4.2	77.7	1.1	.	69.7	72.7
Bone Meal	6.5	62.7	2.8			26.3	...	..	...	.
Fish Meal	6.3	18.5	13.1	1.0	1.8	59.3	12.4	...	53.5	81.4

With the removal of the butterfat from whole milk, much of the energy content and most of the vitamin A have been lost, but most of the protein, the milk sugars and mineral matter remain; thus skim milk is a valuable feed. Its main uses are in the feeding of calves, pigs and chickens. It is the basic feed for many calves, particularly dairy calves, which are raised by hand and when it is fed with proper attention to cleanliness, temperature, quantities, frequency of feedings and supplemental feeds, it produces good and economical growth. (Full instructions about feeding skim milk to calves are given in a later chapter.)

Skim milk is considered the best protein supplement available to pig raisers. The nutritive ratio is narrower than that of whole milk, giving it particularly good balancing value when fed with farm grains. As a supplement for pigs, skim milk can claim the following merits:

(1) Ease of digestibility.
(2) Highly palatable.
(3) Exceptional quality of protein for support of growth.
(4) Rich in calcium and phosphorus.

There is no greater aid to successful pig production than a steady supply of skim milk. In estimating the value of skim milk and good quality buttermilk, it is considered that five pounds should be worth as much as a pound of mixed grain.

Buttermilk. Canadian Feed Unit Value—0.12
Nutritive Ratio—1:2

Buttermilk to which no wash water has been added, will resemble skim milk closely in analysis and is nearly as valuable for pig feeding. Unfortunately buttermilk which is taken from creameries is often diluted and sometimes contaminated. The rules for feeding buttermilk to pigs are practically the same as for feeding skim milk except that the former is not considered as safe a feed for nursing sows, and some people believe that the incidence of intestinal disorder in young pigs is greater where buttermilk is fed.

Buttermilk of good quality can be fed instead of skim milk to calves.

Whey. Canadian Feed Unit Value—0.08
Nutritive Ratio—1:7.6

Whey which is the by-product from cheese manufacture, retains the milk sugars, a small part of the protein and most of the mineral matter from the original whole milk. Of the milk proteins, the casein goes into the cheese and the albumin is left

Hereford bulls eating grain from an outdoor "feed table"

A top carload of feeder steers

in the whey. Practical feeders have estimated the value of whey at one-half that of skim milk or buttermilk but it seems doubtful if this cheese factory by-product can justify that evaluation; whey has 0.8% crude protein compared with 3.5% in skim milk. Whey is principally a pig feed; but as a protein supplement, it is not nearly as effective as skim milk or buttermilk. If one is watchful of sanitary conditions, whey can be used in feeding dairy calves. Whey taken from the cheese factory tends to be dangerous in spreading disease unless pasteurization is practised.

Tankage

"Feeding tankage is the wet-rendered (tanked under live steam) and/or the dry-rendered residues from animal tissues, suitable for animal feeding and containing not less than 50% of crude protein. It may contain not more than 35% of blood." (Canadian Feeding Stuffs Act).

Where such a product contains less than 50% of crude protein but not less than 40%, it must be sold as Feeding Meat and Bone Tankage.

In the preparation of tankage, the animal tissues, exclusive of hide, hair and horn, are cooked under steam pressure of 40 pounds for from 6 to 8 hours. Thus disease organisms are destroyed.

It will be seen that tankage is a high-protein concentrate, and the nutritive ratio is about 1:0.05. It is used most extensively in supplementing pig rations. Like most products of animal origin, the quality of protein is high and well suited to the needs of pigs. In years past, tankage was fed extensively as the sole protein supplement at from 2% to 12% of the grain but more recently, pig concentrates which include from 30% to 50% of tankage or meat meal have been found to give better nutrition. These concentrates are commonly fed at the levels recommended for tankage alone.

Tankage is rarely used for sheep and beef cattle but quite frequently it is fed in moderate amounts in dairy rations, where it may serve as a source of relatively cheap protein. Dairy cattle have no instinctive fondness for tankage but will take small amounts, say up to a pound or two a day, in grain mixtures. Tankage contains bone and therefore supplies considerable calcium and phosphorus.

Meat Meal. According to the Feeding Stuffs Act, "Meat Scrap or Meat Meal is the dry-rendered and/or the open-kettle-rendered residues from animal tissues, suitable for animal feeding, and containing not less than 50% of crude protein. It shall be free

from blood except in such traces as may occur unavoidably in good factory practice. . . . A product otherwise as defined but containing less than 50% of crude protein shall be designated Meat and Bone Scrap or Meat and Bone Meal, provided that nothing shall be recognized as Meat and Bone Scrap or Meat and Bone Meal which contains less than 40% of crude protein".

Meat meal differs from tankage mainly in the method of preparation and the practical absence of blood from the former. In analysis there is little difference but the proteins in the dry-rendered product are believed to be more digestible and more valuable in nutrition than the proteins in the wet-rendered tankage. Meat meal is probably more suitable for feeding to dairy cows. It can however, be fed to pigs according to the same directions as given for tankage and is most suitable for incorporation in mixed concentrates. It is considered a more valuable feed product than tankage and consequently has a wider sale.

Tankage and meat meal weigh about 6.75 pounds per measured gallon.

Blood Meal. In packing house practice, blood is collected, dried and ground. Some of it is used in making tankage but the product known as blood meal is the richest in protein of any feed available. It contains 75% to 80% crude protein. The quality of the protein is not particularly high, due in part to the high heat to which it is exposed in preparation.

Blood meal might be used in small amounts for pigs and cows but it is not in great demand. It has been fed to advantage at times to unthrifty horses, and blood flour, prepared by a slightly different method is sometimes employed in calf meals.

Bone Meal. The Canadian Feeding Stuffs Act defines Feeding Bone Meal and Feeding Steamed Bone Meal as follows:

"Feeding Bone Meal is the dried, ground product containing over 10% of crude protein, free from objectionable odour, palatable and otherwise suitable for animal feeding, obtained from undecomposed bones which have been cooked to remove excess fat and meat."

"Feeding Steamed Bone Meal is the dried, ground product containing not more than 10% crude protein, free from objectionable odour, palatable and otherwise suitable for animal feeding, obtained from undecomposed bones which have been cooked with steam under pressure."

Bone meal is the calcium-phosphorus supplement in widest use in Canàda. It is a logical choice where deficiency is suspected in cattle, sheep and horses. Phosphorus deficiency has been very apparent in both range and farm herds, especially in

the drier sections of the country. Bone meal can be fed free choice, mixed with salt or added at one or two per cent in the grain. The alternatives to the use of bone meal would be such products as *mono-calcium phosphate* and *bone char*. "Bone Char or Bone Black is the product obtained by charring bones in closed retorts."

All bone meal (excluding bone char) must be labelled to show minimum amount of crude protein and maximum amount of crude fat if in excess of 5%. Bone meal weighs about 8.75 pounds per gallon.

Fish Meal. This product comes entirely from the fishing industry and is made from undecomposed fish, fish heads and fish cuttings. The Canadian Feeding Stuffs Act describes the various fish meals as follows:

"White Fish Meal is the clean, dried, ground residue, containing not more than 4% of oil, from undecomposed, whole, non-fatty, white-fleshed fish, including cod, haddock, hake, cusk, pollock, skates and monkfish and/or cuttings thereof.

"Fish Meal is the clean, dried, ground residue, containing not more than 9% of oil, from undecomposed, whole fish and/or fish cuttings.

"Oily Fish Meal is the clean, dried, ground residue, containing more than 9% of oil from undecomposed fish and/or fish cuttings.

"Fish Residue Meal is the clean, dried, undecomposed residue from the manufacture of glue from non-oily fish.

"Whale Meal is the clean, dried, ground residue after the extraction of oil from undecomposed whale flesh.

"Cod Liver Meal is the clean, dried, ground residue after the extraction of oil from undecomposed livers of the cod."

Fish meal offered for sale must carry guarantees as to minimum percentage of crude protein, maximum of crude fat, maximum of crude fibre if in excess of 2%, and maximum of common salt. Not over 4% of common salt is permitted in fish meal.

In all good grades of fish meal, the protein content is high and the quality of protein is also high. It is rich in calcium and phosphorus and vitamins A, D and B_2. The high biological value of the proteins makes fish meal especially valuable in pig feeding. In areas close to the source of supply, fish meal is used extensively as the main protein supplement for pigs and to a limited degree in raising the protein content of dairy rations. In regions farther inland, fish meal prices seem to preclude extensive feeding and its main use there is in mixed protein-mineral concentrates for pigs. At 15% to 40% of the mixture it can be an important part of any protein-rich concentrate used in supplementing pig rations.

For dairy cows it may be an economical source of protein but should be limited to small amounts of the non-oily meals or a fishy flavour will be imparted to the milk. Cows do not relish this feed naturally but will accept it when it is introduced gradually in grain mixtures.

Fish meal weighs about 5.5 pounds per measured gallon.

Fish Oils

The fish liver oils are the best sources of vitamins A and D for supplemental feeding in Canadian practice. Cod liver oil was long the standard but other feeding oils are now on the market and are quite suitable for general use when vitamin potency is guaranteed. Some fish oils as defined by the Feeding Stuffs Act are:

"Cod Liver Oil is the oil from the livers of the cod.

"Herring Oil is from whole herring or parts thereof.

"Menhaden Oil is oil from whole menhaden or parts thereof.

"Pilchard Oil or Sardine Oil is oil from whole Pacific pilchard or sardine, or parts thereof.

"Salmon Oil is oil from salmon or parts thereof.

"Salmon Liver Oil is oil from livers of salmon.

"Tuna Oil is oil from tuna or parts thereof."

The term "cod liver oil" may be applied legally to oil from the livers of the cod family, including cod, haddock, hake, cusk and pollock. Blended fish oil is from two or more kinds of fish.

CHAPTER VI

ROOTS AND TUBERS

Roots should be classified as watered concentrates rather than roughages. Water content is from 85% to 90% and the dry matter is approximately as digestible as that in farm grains. The roots are highly palatable and have an appetizing and tonic effect on wintering farm animals. They are valuable for young animals and breeding stock and have special value for milking cows being forced for high production. There is no doubt about the suitability of roots as a feed for cattle, sheep and pigs, but there is doubt about the practicability of growing them.

The main objection to roots is the relatively high cost of production per unit of feed nutrients. Labour requirements run high and most studies have shown that corn silage is a more economical source of dry matter by at least 25% or 30%. In addition, there is a storage problem which is a big one in those parts where winter weather is severe.

But in spite of relatively high cost for dry matter, there is a place for roots in Canadian feeding practice. Silage is not suitable for pig feeding while roots are. Dairymen in some instances will place a special value upon roots, and where herds are too small to justify the silo, roots seem to represent the logical alternative in supplying winter succulence for cows.

Roots such as turnips and mangels are usually pulped or sliced before feeding but this is not necessary for animals with sound teeth. Pulping makes it possible to mix the roots with other feeds such as chaffed dry roughage.

For milking cows the amounts fed daily range from 20 to 60 pounds per animal while in Britain where roots are grown extensively for feeding, the daily allowance will often exceed 100 pounds. In making substitutions in farm rations, five pounds of roots will replace one pound of hay.

Mangels. Canadian Feed Unit Value—0.07
Nutritive Ratio—1:7.1

In root-growing sections, mangels have gained popularity at the expense of turnips. Higher yield is one reason as mangels are the highest yielders of all roots. Mangels are popular with

ROOTS AND TUBERS

	Average Composition						Digestible Nutrients in 100 lb.			Total Digestible Nutrients
	Moisture %	Ash %	Fat %	Fibre %	Nitrogen Free Extract %	Crude Protein %	Fat	Carbo-hydrates	Crude Protein	
Mangels	90.4	0.9	0.1	0.8	6.5	1.3	0.1	6.2	0.9	7.3
Swede Turnips	88.8	1.0	0.2	1.3	7.5	1.2	0.2	7.8	1.0	9.3
Fall Turnips	90.9	0.8	0.2	1.1	5.8	1.2	0.2	5.7	0.7	6.9
Carrots	88.0	1.1	0.2	1.0	8.4	1.3	0.2	8.3	0.9	9.6
Sugar Beets	83.2	1.2	0.1	1.0	13.0	1.5	0.1	12.4	1.2	13.9
Potatoes	79.0	1.0	0.1	0.5	17.3	2.1	0.1	15.7	1.1	17.0

dairymen. Unlike turnips, mangels will not taint the milk of cows feeding on them. Mangels are particularly popular with dairymen who are forcing cows for high production.

Mangels are probably the best and most appropriate of the roots for pigs. For this class of stock they need not be pulped although pulping will permit mixing the mangels with grain. Feeding mangels to pigs does not reduce the need for protein supplements.

Mangels are quite suitable for sheep but when fed to males, either rams or wethers, there is a danger of calculi forming in the urethra, and causing death. The same occurs in steers and bulls feeding on mangels, but more rarely.

Swede Turnips. Canadian Feed Unit Value—0.11
Nutritive Ratio—1:8.3

It will be noted that swede turnips have slightly higher content of dry matter than fall turnips or mangels. Mangels and fall turnips give a higher yield but swede turnips have better keeping qualities. The fact that turnips taint milk unless fed to the cows after milking, has lessened their popularity with dairymen. Their best use is for beef cattle and sheep. Beef cattle may receive from 10 to 50 pounds a day depending on the size of the animals and supply of turnips. Sheep prefer swede turnips to mangels and from 2 to 4 pounds daily may be fed to ewes and 2 to 3 pounds to fattening lambs.

The area planted in turnips in Canada in 1943 was 163,000 acres.

Fall Turnips. Canadian Feed Unit Value—0.07
Nutritive Ratio—1:8.8

These turnips are heavier yielders than swedes but are more watery and lack keeping qualities. Dry matter runs less than 200 pounds per ton. They are grown for feeding in fall and early winter and their range of use is the same as for swedes.

Carrots. Canadian Feed Unit Value—0.11
Nutritive Ratio—1:9.7

Carrots make an especially high quality feed but the yield is low compared with turnips and mangels. Furthermore they are difficult to store. Consequently, they are grown only for special purposes, sometimes for test cows and occasionally for show or fancy horses. They are never fed in the amounts recommended for other roots. One of the nutritional peculiarities about carrots is the high content of carotene, the precursor of vitamin A.

Sugar Beets. Canadian Feed Unit Value—0.16
Nutritive Ratio—1:10.5

Sugar beets are higher in dry matter and net feeding value than mangels and turnips, but yield is definitely lower, and they are more difficult to harvest. They have unusually good appetizing qualities and are highly regarded by feeders of test cows but they are not economical to grow for stock and therefore not widely used.

Potatoes. Canadian Feed Unit Value—0.23
Nutritive Ratio—1:14.5

Potatoes are higher in feed unit value than the roots but not as palatable and appetizing. They are rarely grown expressly for feeding purpose and never fed in such large quantities as roots. Bloating and digestive troubles may follow heavy feeding, and 25 to 30 pounds a day are considered enough for cows. At this rate they have about the same value, pound for pound, as corn silage. Potatoes, particularly medium sized ones, should be pulped or sliced for cattle to avoid the danger of choking.

Potatoes are not suitable for horses. Sheep might be given up to 2½ pounds per head daily. Potatoes are better for pigs than for other classes of stock. Cooking however is important in preparing the tubers for pigs and the cooked product can be mixed with grain feed. They should never be fed to replace more than one-third of the grain for pigs. When cooked, 450 pounds of potatoes will take the place of 100 pounds of mixed grain. It is to be remembered that potatoes are very low in protein and lime, and proper supplementing is essential.

Those who feed potatoes should be familiar with the possibilities of solanin poisoning. Potato sprouts carry a concentration of the poison and are the greatest source of danger, but peelings, spoiled potatoes and water in which potatoes have been cooked may carry sufficient of the poisonous principle to do injury.

Miscellaneous Succulent Feeds

Pumpkins. These resemble roots in feeding value but are more likely to be a by-product of the garden than a primary feed. The labour requirement in growing them is too high to make their production attractive to stockmen. When available, they would be most suitable for cattle and pigs.

Cabbage. This is not an economical feed to grow and store but is highly regarded by sheepmen and sometimes fed to dairy cattle. Those who fit sheep for show and sale will find cabbage to be especially beneficial.

Apples and Apple Pomace. Unmarketable apples may be fed in moderate amounts to cattle and pigs. For cattle, they would have a value somewhat under 50% of the value of corn silage. Apple pomace is the by-product from apples used in making cider or vinegar. Used as feed, it has about 75% as much value as corn silage. Apples contain about 82% water and the pomace, 75%.

Garbage. Garbage is essentially a pig feed, but because of the great variation in the product, it is difficult to accurately estimate its value. Generally, it is composed of scraps, peelings and spoiled food. There is danger from broken glassware and other foreign matter, and an added danger of disease transmission when the product is fed in the uncooked state. Garbage should therefore be cooked for pigs. Large consumption may result in low quality pork. When fed at moderate levels and in conjunction with grains and suitable supplements, good grades of garbage are useful in pig feeding.

CHAPTER VII

SILAGE

Silage is succulent feed, generally palatable and healthful. Crops like corn and sunflowers used for silage will usually return more in digestible nutrients per acre than hay crops, although alfalfa hay is sometimes an exception. A yield of seven tons of corn silage per acre will net 2,380 Canadian Feed Units compared with 1,120 from an acre-yield of one ton of grass hay, and 2,080 from an acre-yield of two tons of alfalfa hay.

But there are arguments for and against the practicability of growing silage, and feeders should consider cost of a unit of feed material as well as yield. In some parts of the country farmers are convinced that they can produce a pound of dry matter in hay and grain more cheaply than in silage and roots. American authorities have stated that silage is likely to represent an economic advantage for the feeder when its cost per ton is not more than one-third that of hay. Of the Canadian producers, the dairymen are the most enthusiastic about silage and unquestionably the product has more to offer for milk making than in any other line of production.

Clearly there are both advantages and disadvantages in silage for feed and the farmer's decision to grow it should be made only after a complete review of the economics of its production. Its position can be summarized as follows:

Advantages

(1) Succulent feeds can be stored for winter use.
(2) Silage is palatable and laxative.
(3) Silage can be carried from one year to the next.
(4) Silage can be prepared in weather which is unfavourable for haying.
(5) Some coarse stemmed plants can be made more acceptable for feeding.
(6) Certain weeds can be made acceptable for feed.
(7) Silage on basis of dry matter is more economical to grow than roots.
(8) Silage crops often produce more digestible nutrients per acre than common hay crops.
(9) A row crop like corn fits well into a crop rotation.

Disadvantages

(1) Labour costs in making silage are relatively high.
(2) The silo and equipment increase overhead costs.
(3) Spoilage losses sometimes run high.
(4) Uncertain yields of silage crops will increase costs.
(5) Silo filling may conflict with harvesting operations.
(6) After silo is opened, feeding must continue in order to prevent spoiling.

SILAGE

	Average Composition						Digestible Ingredients in 100 lb			Total Digestible Nutrients
	Moisture %	Ash %	Fat %	Fibre %	Nitrogen Free Extract %	Crude Protein %	Fat	Carbo-hydrates	Crude Protein	
Corn silage.	75.5	1.5	0.8	6.1	13.9	2.2	0.4	13.0	1.1	15.0
Oat silage	67.3	2.3	1.4	10.5	15.3	3.2	0.7	14.7	1.9	18.2
O.P.V. silage..........	73.3	2.0	1.3	8.5	11.8	3.1	1.0	13.1	2.0	17.4
Sunflower silage.........	77.1	2.3	1.0	7.0	10.0	2.6	0.7	10.9	1.3	13.8
Sweet Clover silage......	74.7	2.3	1.0	7.5	11.3	3.2	0.5	10.8	2.4	14.3

Corn Silage. Canadian Feed Unit Value—0.17
Nutritive Ratio—1:12.6

Corn is a universal favourite, being one of the most palatable of silage crops. It is rich in carbohydrate material and when properly prepared will come out of the silo with good colour and a pungent aroma. The crop is planted in rows about 36 inches apart, and a little thicker than corn for grain. It makes the best silage if cut well past the milk stage or when the kernels are hardening. Better to cut on "the green side" however, rather than risk freezing. The amounts which may be fed to various classes of farm animals are set down later in this chapter.

Oat Silage. Canadian Feed Unit Value—0.18
Nutritive Ratio—1:8.6

Green oats are sometimes used for silage in northern districts. The quality can be good and for practical purposes, the equal of corn.

O.P.V. Silage. Canadian Feed Unit Value—0.18
Nutritive Ratio—1:7.7

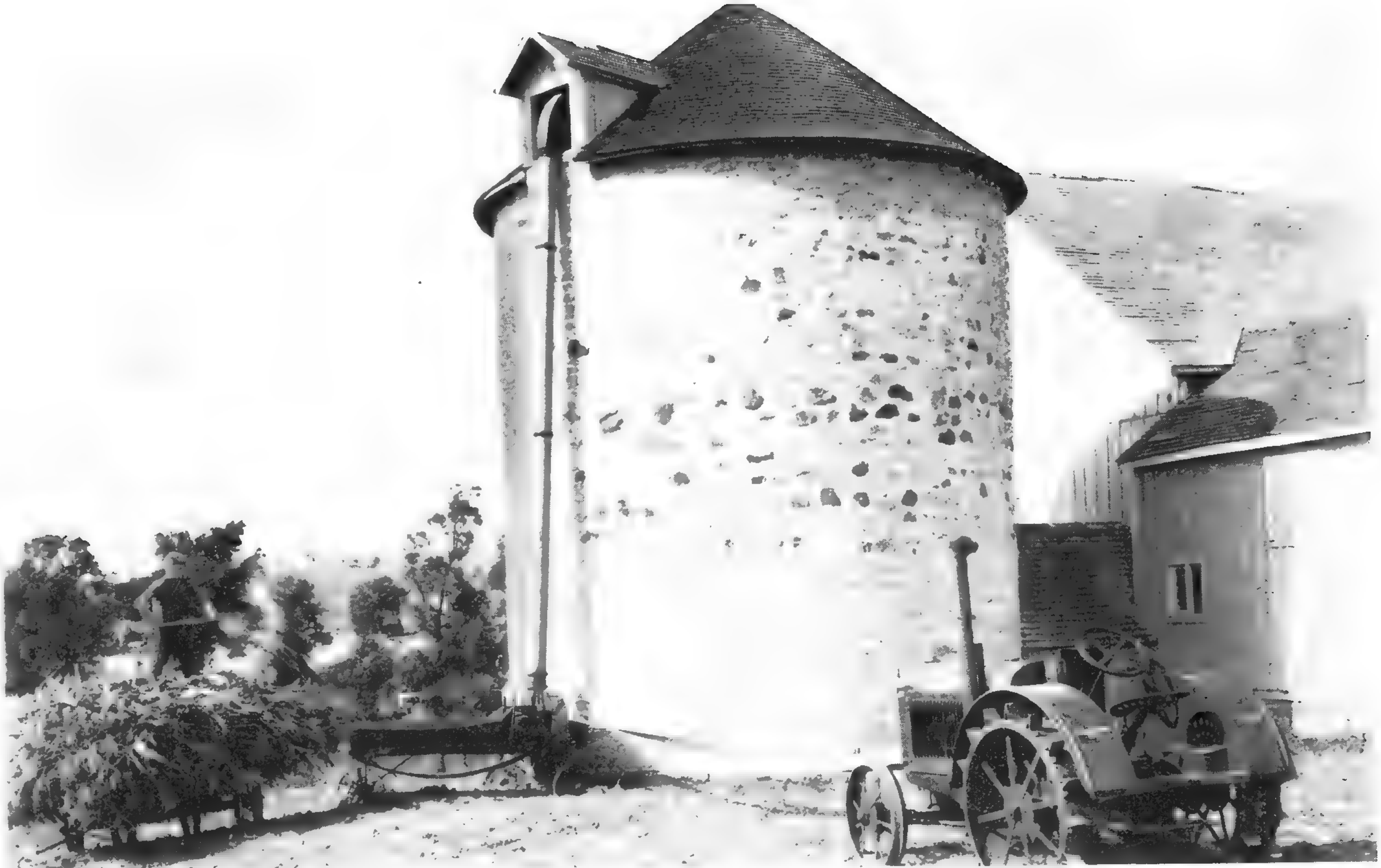
This combination of oats, peas and vetches has been grown for silage purposes in some northern districts of Eastern Canada. The presence of the oats makes for a better quality of silage than would be possible with the legumes alone.

Sunflower Silage. Canadian Feed Unit Value—0.15
Nutritive Ratio—1:9.6

Sunflower silage cannot claim as much palatability and general favour as corn silage but it has been used acceptably in districts where the growing season was too short for corn. Sunflowers are planted in rows 36 inches apart, allowing about 10 to 12 pounds of seed per acre. The best time to cut for silage is when half the flowers are in bloom. In feeding sunflower silage, give slightly lower daily amounts than you would if corn silage was fed.

Sweet Clover Silage. Canadian Feed Unit Value—0.14
Nutritive Ratio—1:5.0

All the legumes have been disappointing as silage unless mixed with non-legume plants or treated with molasses or other carbohydrate materials. The high protein and correspondingly low sugar content is the reason. Nevertheless, the high protein of legumes is valuable if proper preservation can be achieved and ensiling with molasses at the rate of 40 or 50 pounds of molasses per ton of cut silage is recommended. The



Silo filling scene in Eastern Canada

molasses should be diluted with warm water and sprayed over the cut feed as it is tramped in the silo. In providing extra carbohydrate material of a readily available kind, the molasses allows for more organic acid and thus less putrefactive action. The resulting silage will be sweeter and less disagreeable in odour than that of the legumes ensiled alone.

Other Silage Products

Sorghum is used for silage in parts of the United States but not often in Canada. It has a high sugar content and makes a palatable silage. It is not as easily grown in northern areas as corn and sunflowers.

Russian thistles have been ensiled as an emergency crop in the West but not with much satisfaction because of the extreme heating, discolouration, ill smell and unpalatability. Better success was achieved with the hay from Russian thistles.

Other products sometimes used for silage are beet tops, beet pulp and cannery refuse.

The Silo. Making silage by placing the green fodder in stacks and packing thoroughly is possible but, on the whole, not very satisfactory. The loss due to spoiling over the entire surface of the stack silo is great and may represent close to one-third of the total. A closed silo is generally considered essential.

The requisites of a good silo are:

(a) Airtight walls.
(b) Smooth and strong sides, perpendicular or nearly so.
(c) Good depth to give pressure and ensure thorough settling.
(d) Cylindrical shape. (Cylindrical shape is not essential but is preferable because settling is more uniform and complete in a silo without corners.)

Silos in common use have been of three types; each has its advantages and disadvantages.

(a) Upright silos constructed from wood, cement or tile.
(b) Pit silos.
(c) Trench silos.

Upright Silo. The upright type is most common. Cement makes the most durable silo but freezing is a greater hazard in this kind. Tile silos are more costly but possess about the same degree of durability and fire resistance as cement and have the added advantage of being more frost proof. The wooden stave silo is the easiest and cheapest of the upright silos to erect and continues to be the most popular.

Pit Silos. The pit silo usually represents more permanency than the trench and is more resistant to frost than the upright type. The main storage will be in the circular pit but its capacity is often increased by a structure extending above the ground level. A permanent structure should be equipped with a concrete curb and a cement lining. This form of silo has been used successfully in arid and semi-arid regions. It must be built where there is good natural drainage. The difficulty of lifting and removing the silage from a pit is one objection often raised against this type.

Shorthorn bull, Broadacres Demonstrator, Grand Champion at Saskatoon Exhibition, 1940

Trench Silo. A trench silo is simple and cheap to construct and is quite practical under emergency conditions or where feed reserves are to be carried over for a year or two. The trench is usually about 14 feet wide, 7 feet deep and of any acceptable length. A trench of such depth and width and 30 feet long would hold 50 tons of silage. It is easy to fill with silage and packing can be achieved effectively by keeping a horse or tractor moving over the mass. An objection to the trench is its unsightly appearance when not in use.

Size of Silo. A cubic foot of settled corn silage will weigh roughly 40 pounds; sunflower silage is heavier. Once the silo is opened, the feed should be used steadily, an even layer being removed from

the mass each day. This is to avoid spoiling on the surface and at least two inches of silage should be taken for feeding each day. Thus it is important to know the weight in two-inches of silage from silos of different sizes. The size of the silo should bear a relationship to the size of the herd to be fed and the daily requirements.

The capacity of a cylindrical silo can be determined readily; multiply the square of the diameter in feet by 0.7854 to give the area of the floor and then multiply the result by the height in feet to give the cubic content. In a high and well settled silo, there will be a ton of silage for every 50 cubic feet. The following table is to show the tonnage in silos of different sizes. It should be noted that allowance is made for the fact of less density and weight per cubic foot where the silage mass does not have the benefit of height in the silo.

Height of mass of Silage	*10 feet*	*12 feet*	*14 feet*	*16 feet*	*18 feet*
20 feet	24 tons	32 tons	45 tons	62 tons	80 tons
22 feet	27 tons	38 tons	52 tons	70 tons	90 tons
24 feet	31 tons	44 tons	60 tons	78 tons	100 tons
26 feet	34 tons	49 tons	66 tons	87 tons	111 tons
28 feet	38 tons	55 tons	73 tons	95 tons	122 tons
30 feet	43 tons	60 tons	80 tons	104 tons	133 tons
32 feet	48 tons	66 tons	88 tons	114 tons	145 tons
34 feet	——	72 tons	97 tons	125 tons	159 tons
36 feet	——	80 tons	105 tons	137 tons	173 tons
38 feet	——	——	114 tons	148 tons	187 tons
40 feet	——	——	123 tons	159 tons	202 tons
Amount to be fed daily to remove two inches	525 lb.	750 lb.	1,025 lb.	1,330 lb.	1,700 lb.

Changes within the Silage. When silage is placed in the silo, fermentation, due to the action of enzymes and bacterial organisms, begins almost immediately. The bacteria multiply quickly and temperature near the surface will go to 130°F. When Russian thistles were ensiled experimentally in 1937, it was observed that the temperatures in the top two feet of silage remained close to 160°F for more than a month.

Bacteria normally increase from about three million per cubic centimeter to a billion or more per c.c., in a few days. Oxygen is consumed and carbon dioxide released. It is on account of the release of carbon dioxide that a half-filled silo may represent danger for the person entering it. In cases of doubt, a lighted lantern should be lowered into the silo; if the carbon dioxide is high, the light will go out.

When the oxygen in the air spaces in the mass of silage is exhausted, the bacteria will attack the sugars, producing organic acids which help to check putrefactive organisms. Ultimately

the fermentation will likewise be checked by the increasing acidity. The foul odour arising when legumes are ensiled alone indicates some degree of putrefaction due to insufficient readily available carbohydrate material to allow the needed organic acids.

A.I.V. Silage. Dr. A. I. Virtanen of Finland developed a silage-making technique which has become popular in parts of the Old Country and known as A.I.V. It consists of treating the freshly ensiled forage with a weak solution of hydrochloric acid to permit preservation without fermentation or putrefaction. The pH (acidity) of the treated silage should be between 3.6 and 4. By this method even the legumes can be ensiled successfully and the claim is justified that the vitamin A value of the green forage is not lost. One objection is the tendency to acidosis in the animals eating this silage treated with a mineral acid and there is an increased need for a feed supplement like ground limestone.

Making Silage. It is important that the proper technique in making silage be followed. Here are the essentials:

(1) A suitable crop for silage purposes.

(2) Harvesting at correct stage.

(3) Cutting with ensilage cutter to permit best degree of packing.

(4) Proper moisture at time of ensiling.

(5) Thorough packing to exclude air.

(6) Capping the filled silo to prevent excessive spoiling.

Silo Filling. To produce the best silage and make removal from the silo easy, cutting with an ensilage cutter is necessary. Cutting to lengths of three quarters of an inch is considered best and it is essential that the knives be in good condition and sharp.

Silage from plants which have become unduly mature or silage which has become dry, should have water added to permit the best packing and to exclude air. It is a common practice therefore to pass a stream of water into the blower of the cutting box or directly onto the pile of cut ensilage as it accumulates in the silo.

The importance of thorough tramping of the cut ensilage can scarcely be overstated. The cut material should be spread as it is blown into the silo and tramping should be done continuously. The silage around the outside will require the most attention in tramping because it will settle more slowly. Some tramping around the walls for several days after the silo has been filled is a good plan. With the trench silo, lack of depth and lack of weight of silage are handicaps, but more effective tramping by means of a horse moving about on the surface will partly com-

pensate for lack of weight. During the filling of an upright silo, the tramping is a full-time job for a man.

A few days after the silo has been filled, there will be room for more silage and refilling may be considered. Finally, the mass in the filled silo should be covered or capped with a good layer of wet straw in order to reduce the spoiling which always occurs at the top of the mass.

Using Silage. This feed is too soft for working horses and too fibrous for pigs, but for cattle and sheep it is an excellent form of roughage. Its greatest value is in rations for milking cows and the largest number of silos will be seen in the milk producing sections of the country. Three pounds of ensilage will replace a pound of hay in rations for cattle and sheep. Pregnant ewes should not receive more than a moderate allowance of silage owing to the tendency toward weakness in the lambs. More than five or ten pounds of silage daily should not be given to breeding bulls because of the danger of "slow breeding".

The amounts of corn silage which can be fed with safety are:

Cows in milk	30 to 40 pounds per day
Dry cows	25 to 35 pounds per day
Wintering beef cows	25 to 40 pounds per day
Fattening steers	10 to 30 pounds per day
Ewes in lamb	1 to 2 pounds per day
Fattening lambs	1½ to 2 pounds per day
Idle horses	10 to 20 pounds per day

Spoiled silage should be discarded. This is particularly important in the case of sweet clover silage showing any degree of spoiling.

CHAPTER VIII

PASTURE AND HAY

It is not often that the best feed is the cheapest but such is the case with grass where herbivorous animals are concerned. Milk has been acclaimed the most nearly perfect food but for mature cattle, horses and sheep, grass is the most natural, the most nearly balanced and the most healthful of all feeds. Indeed it can be argued that Canadian stockmen have given all too little thought to the supreme value of good grazing and too little attention to the care and productivity of the pasture lands, native and cultivated.

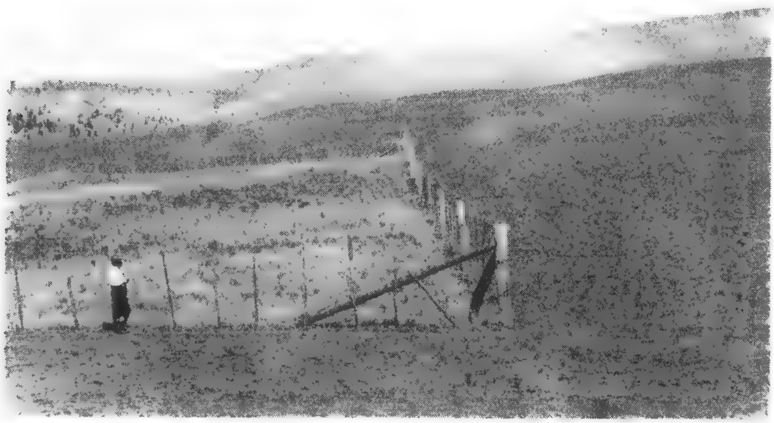
Early in the history of Western agriculture, there was an abundance of native grass for both hay and pasture but as the land was given over to wheat, the prairie grasses were destroyed; in many instances the good native species were sacrificed before it was discovered that the particular districts were unsuited to wheat. But drifting soil, failing markets for wheat and a better understanding of land utilization combined to make a regrassing programme imperative. It was not easy however to re-establish the grass and that phase of prairie rehabilitation gave rise to numerous disappointments. Crested wheat grass, a native of Russia and Siberia was introduced to the United States in 1898 and later it was brought to Western Canada by the University of Saskatchewan; owing to hardiness and drought resisting qualities, it has served to fill an important place on the prairies.

Pasture Management

The mistakes made in this country in grassland conservation, coupled with a knowledge of the essential part grass has played in the agriculture of the Old World, should make Canadians intensely conscious of the need for attention to this important branch of husbandry. There are still almost 20 million acres of land being used for range purposes in Western Canada, to say nothing of small and domestic pastures. That vast area of grassland represents an important part of the natural resources of the nation and a part deserving more attention than it has received in the past.

Grasses are peculiar in that they make new growth at the

base of the leaves and can therefore grow again after being eaten down. Young grass or new growth is most palatable to all animals and contains the highest percentage of protein. In early stages of growth, crested wheat grass and brome will contain up to 25% of crude protein; but with maturity, the protein content may shrink to 6% or 8% of dry matter. As the plants mature, the protein content drops and fibre increases. Nevertheless, the maximum return from pastures is secured when the best balance between grass and animals is maintained. That balance demands a safeguard against overgrazing but at the same time, it calls for enough stock to eat the grass down reasonably well and thus ensure continued new growth. When pasture "gets ahead" of the grazing animals, so that the plants approach maturity, it must be evident that the field is understocked and the production of the most nutritious young growth is being curtailed.



Experimental conservation plot on an overgrazed Chilcotin range

Overgrazing

Overgrazing is to be avoided at any time, but more particularly in periods of drought. Close grazing however, will not injure the creeping grasses like brome as much as it will the bunch grasses. The unfavourable effect of overgrazing will not be noticeable at first but it will result in lowered carrying capacity for several years. Soil erosion and excessive growth of unpalatable weeds are common results of overgrazing.

Of the non-grasses which are common on overgrazed ranges

of the short grass plains, prairie sage (*Artemesia frigida*) and little clubmoss (*Selanginella densa*) are most conspicuous. Sage brush is wide-spread on the range and while cattle and horses do not eat it, sheep will take it fairly readily. Buckbrush is a weed which causes annoyance on some native ranges but mowing at proper times will eradicate it. Late May or early June would be most effective and mowing at that time for three consecutive years will usually eliminate it.

The areas around the water troughs or water holes or wherever animals congregate regularly will be the first to suffer from overgrazing. Uniform grazing is difficult on big ranges or where stock must travel two miles or more to water. In that connection it should be pointed out that cattle and sheep should not be expected to travel over two and one-half miles to water, and in rough or wooded country the maximum grazing distance from water should not go beyond a mile. With a good distribution of salt licks and shelters there will be more uniform grazing.

With sheep on the range, large bands do more injury to the range grasses than small ones. Unless conditions are exceptionally favourable, sheep flocks on summer range should not exceed 1,000 ewes with their lambs. This is for the good of the range as well as the sheep. Flocks of less than 400 ewes with their lambs will scarcely justify the cost of herding but lambs from the smaller bands will usually outweigh those from the big flocks.

Deferred Grazing. Deferred grazing has seemed to have a good deal to offer in conservation in some parts of the Western range. It involves withholding a portion of the grass from the stock during the early season or until the seed has had a chance to form. After the seed has set, the areas can be grazed; fortunately, the native prairie grasses make very acceptable grazing even after the seed has been dropped. Grassland recovery by this method necessitates division of the ranges by crossfences.

Early Spring Grazing. Grazing in the early spring when the land is soft will injure the plants; this is of special importance in domestic pastures. The ground should be firm and the growth well started therefore before the grazing herds are released upon a field of domestic pasture. Animals may pasture on sweet clover from the time plants are five or six inches high and grazing on alfalfa can begin when the growth is about five inches.

Hohenheim System. This is a system of pasture management which was developed in Germany in 1916 and holds some points of considerable interest. It is based upon the principle that more extensive use of young grass, rich in protein, will reduce greatly the necessity of supplying high priced concentrates to the grazing

animals; it was adapted mainly to dairy cattle. It embodies four main features:

(a) Division of the pasture into four or more fields or paddocks.
(b) Forcing luxuriant growth by means of heavy applications of fertilizer, mainly nitrogenous fertilizer.
(c) Division of the herd into groups, e.g., producers and non-producers or high producers, low producers and dry cattle.
(d) Rotational grazing with the high producers getting the best grass and other groups following them in the order of their production.

Yields of Pasture

The yield of pasture can often be increased from 25% to 40% by the application of barnyard manure or artificial fertilizer. An application of 5 to 10 tons of manure per acre will help in renovating a run-down pasture. In the case of small and high yielding domestic pastures, an advantage can be gained by scattering the manure droppings at several times during the season. This will increase productivity of the fields and can be done easily by the use of a chain-type harrow. Quite obviously, different plants give different yields. It is now well established that a combination of a grass and a legume will result in bigger yields than could be obtained from either alone. The best domestic pastures have from 10% to 25% of clover or alfalfa. A combination of brome grass and alfalfa is proving very popular with live-stock feeders in Western Canada. It gives a high yield of good quality feed.

Just how much grazing should one expect from an acre? This is not an easy question because of the varied conditions of soil and rainfall. On the short grass plains of Southern Alberta, ranchers require from 40 to 60 acres to keep a cow for one year. Under very favourable conditions of domestic pasturage, one acre may carry a cow for the grazing season. Well nourished pastures in Ontario are expected to support milking cows at the rate of one cow per acre for a grazing period of 150 days; such cows would get no other feed, except the very heavy producers which would receive an allowance of concentrates. It will be pointed out too that where good cows are concerned, a good pasture should yield at least 4,000 pounds of milk per acre during the grazing season.

Six to seven mature sheep will require about the same amount of grazing as one cow.

A home made buck-rake which will save much time and labour at haying

Combination sweep and stacker for use with tractor

Making Hay

Hay is the most universally used roughage for farm animals during the non-grazing seasons. Depending upon methods followed, stockmen make or lose more money than they realize at haying time. The time of cutting hay is important and the objective should be to get the largest quantity of the best quality. Cutting too early means lower yields of dry matter and cutting late gives a fibrous hay of low palatabilty and low digestibility. Early cut hay will have the highest content of protein.

Crested wheat grass and slender wheat grass should be cut just before blooming or about a week after heading. It is a mistake to leave these until after flowering. Brome can be cut successfully at a slightly later stage. These grasses have a comparatively low moisture content and can be raked and stacked soon after cutting, even as soon as 24 to 48 hours after, if there is no moisture from rain or dew and the weather is favourable.

The legumes on account of their protein, mineral and vitamin content, can be the most valuable roughage on the stock farm but a good deal will depend upon stage of cutting and success in curing. The two essentials are to cut in good time and make every effort to save all the leaves. About 40% of the total harvested weight of legume hay is in the leaves and thus a higher percentage of the feeding value; yet too often, the alfalfa or clover hay arrives at the mangers almost totally without leaves. It is suggested that legumes for hay be raked in the opposite direction from that in which the mower is hauled in order to reduce exposure of leaves. Raking should be done when the leaves have wilted but not dried and if possible, the hay should then be placed in coils to complete curing; the biggest loss of leaves occurs when curing is accomplished in winrows or when coiling is late. The use of tripods has something to offer in curing hay when weather conditions are unfavourable.

To minimize losses in feeding value, hay should be placed in stack or mow just as soon after mowing as that can be done with safety. Exposure to rain results in serious losses, especially of the more soluble and thus more available constituents; protein, fat, soluble carbohydrates, minerals and the vitamin value will be lessened. Under very unfavourable haying conditions coupled with poor management, the losses in net energy may run as high as 50 or 60 per cent.

Stacking

If hay is dry, big well-made stacks are conducive to the best keeping. The salting of hay is an ancient practice, the purpose being to reduce the danger of spoiling when the hay placed in

Modern haying equipment saves time and labour

Extra hay in good stacks contributes to the stockman's security

the stack is considered too damp for safe keeping. The exact benefit of the salt in this case is not clear but 15 or 20 pounds per ton of hay must have some effect in preventing spoiling, and in addition it helps to make the feed more palatable to the stock.

Hay if well stacked is one of the most satisfactory feeds to carry over from year to year and thus forms a reserve for years of crop failure. Every stockman should know that colour in hay should be preserved. Hay with a rich green colour is actually worth more in dollars per ton than hay which is bleached or has a dead appearance. The rich green colour means carotene or vitamin A.

To Determine Tons of Hay in Stack or Mow

The first step in estimating hay tonnage is to determine the cubic contents in feet. In a symmetrical mow it is a small matter to multiply length by width by height in feet. For hay in a rectangular stack, the cubical contents can be obtained by multiplying length by width by 3/10 of overthrow in feet. With the number of cubic feet of hay ascertained, the next and last step is to divide by a figure which represents the number of cubic feet in a ton of the hay in question. In the selection of this figure lies the biggest chance of error.

It will be understood that the weight of hay varies a good deal depending upon texture, size of pile, and period of time in stack or mow. But the following figures for cubic feet per ton will give some guidance:

	Domestic grass hay or native midland hay	*Prairie hay*	*Legume hay*
Hay in stack less than 30 days	590 cubic feet	540 cu. ft.	620 cu. ft.
Hay in stack 30-60 days	510 cubic feet	460 cu. ft.	540 cu. ft.
Hay in stack more than 60 days	470 cubic feet	420 cu. ft.	500 cu. ft.

Straw will range from 700 to 1,000 cubic feet per ton, depending upon length of time in the stack.

And here is what John J. Ingalls wrote about it:

"Grass is the forgiveness of nature—her constant benediction. Fields trampled with battle, saturated with blood, torn with ruts of cannon, grow green again with grass, and carnage is forgotten. Streets abandoned by traffic become grass-grown like rural lanes, and are obliterated. Forests decay, harvests perish, flowers vanish, but grass is immortal. Beleaguered by the sullen hosts of winter, it withdraws into the impregnable fortress of its subterranean vitality, and emerges upon the first solicitation of spring. Sown by the winds, by wandering birds, propagated by

the subtle horticulture of the elements which are its ministers and servants, it softens the rude outline of the world. Its tenacious fibers hold the earth in its place and prevent its soluble components from washing into the wasting sea. It invades the solitude of deserts, climbs the inaccessible slopes and forbidding pinnacles of mountains, modifies climates, and determines the history, character and destiny of nations. Unobtrusive and patient, it has immortal vigour and aggression. Banished from the thoroughfare and field, it bides its time to return, and when vigilance is relaxed, or the dynasty has perished, it silently resumes the throne from which it has been expelled, but which it never abdicates. It bears no blazonry of bloom to charm the senses with fragrance or splendour, but its homely hue is more enchanting than the lily or the rose. It yields no fruit in earth or air, and yet should its harvest fail for a single year, famine would depopulate the world."

CHAPTER IX

LEGUMES FOR HAY AND PASTURE

Most of the common forage crops can be used for either pasture or hay but usually a species is better suited to one purpose than the other. In any case it is important that stockmen be familiar with grasses and clovers and their characteristics as feeds.

This group of plants belonging to the family Leguminosae is of extreme importance in agriculture as soil improvers and as sources of oil, grain and forage. The legumes, of which alfalfa and the clovers are well known, are the only plants which possess the ability to incorporate atmospheric nitrogen into the soil and thus enrich it. Nitrogen is an essential plant food and one for which artificial fertilizer is frequently purchased.

The ploughing down of a legume crop will restore both nitrogen and organic matter, but even if nothing remains of the crop except the roots and stubble, the advantage in accumulated nitrogen is great. It is estimated that with a ton-yield of alfalfa hay from an acre, some 50 pounds of nitrogen will be present in the hay and close to 20 pounds will be returned to the soil through the medium of roots and stubble. Furthermore, the roots penetrate deeply and tend to open the soil and leave it in an improved physical state.

The growing of legumes for forage offers a means by which the farmer can more nearly meet the requirements of his livestock with home produced feeds. They are high in protein, the feed constituent for which supplements must be purchased frequently, and they are rich in essential minerals and vitamins. Legume hay is an alternative for high priced meals and cakes for feeding.

Alfalfa is the "King of Forages" and where it can be grown successfully, it will do more to raise the general level of animal nutrition than any other single feed crop.

Alfalfa. Perennial.
Canadian Feed Unit Value of Hay—0.52
Nutritive Ratio—1:3.4
Palatability—Very High.

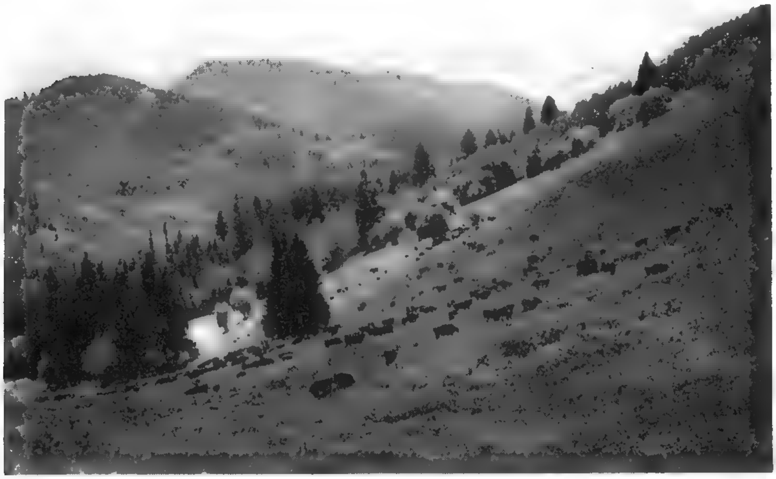
Alfalfa is the most valuable forage crop grown for feed. Where it can be grown successfully it will produce a large tonnage of

LEGUMES FOR HAY AND PASTURE

	Average Composition						Digestible Ingredients in 100 lb.			Total Digestible Nutrients
	Moisture %	Ash %	Fat %	Fibre %	Nitrogen Free Extract %	Crude Protein %	Fat	Carbohydrates	Crude Protein	
Alfalfa hay......	8.7	8.5	2.6	27.5	37.3	15.4	1.2	36.8	11.5	51.0
Alsike hay	10.9	8.5	2.6	25.3	39.4	13.3	1.1	37.2	8.5	48.2
Sweet clover hay	8.1	7.3	2.5	28.8	38.6	14.7	0.8	38.1	11.0	50.9
Red clover hay........	13.3	7.0	3.3	24.5	38.9	13.0	1.9	38.8	8.2	51.3
Soybean hay.........	9.7	8.1	3.5	24.3	38.3	16.1	1.5	37.9	12.1	53.4
Field pea hay	9.5	7.8	3.4	28.2	34.7	16.4	2.0	35.0	10.9	50.4
Green alfalfa..	77.0	2.2	0.9	6.0	9.3	4.6	0.5	8.7	3.2	13.0
Green sweet clover......	79.5	1.5	0.8	6.1	9.4	4.0	0.4	8.9	2.8	12.6

dry matter and the biggest yield of protein per acre of all feed crops. Alfalfa makes a good pasture and is superior to all other forages when made into hay.

As a pasture crop, alfalfa starts growth early in the season and continues late in the autumn. There is no question about the palatability and nutritional value of alfalfa pasture but the danger of bloating in cattle and sheep which graze on it is sufficient to discourage many stockmen. The hazard is greatest when the forage is wet with rain or dew and when the cattle are hungry and inclined to gorge. The reasonable precautions there-



A cattle range, interior of British Columbia

fore are to keep the animals from grazing when the alfalfa is damp and to introduce hungry cattle or sheep to it very gradually. For pasture purposes, an alfalfa-grass mixture is safer and more practical than alfalfa alone. Nevertheless, straight alfalfa is probably the best of the permanent pastures for pigs. Alfalfa does not withstand heavy grazing as well as sweet clover.

As a hay crop, alfalfa is supreme, being a heavy yielder and possessing relatively large amounts of essential constituents which are frequently deficient in common farm grown feeds. From one to three tons of hay per acre can be harvested. It does well on irrigated land and under favourable conditions, up to three cuttings a year can be recovered.

In the preparation of hay, every care should be taken to cut at the correct stage, retain the leaves and retain the rich green colour. Alfalfa should be cut for hay when the plants are

beginning to bloom or when 10% of the flowers are in bloom. All possible speed consistent with safety should be made in getting the cut hay into coil or stack. The hay must remain in the swath until it is reasonably dry but unnecessary exposure will result in loss of leaves and feed value.

Alfalfa hay has wide use for dairy cattle, beef cattle, sheep, pigs and horses. No hay can be used so widely and to such good nutritional advantage.

Here are some appropriate uses:

(a) Alfalfa hay is the dairyman's favourite among dry roughages.
(b) Where it can be grown successfully and economically, its use should dominate in feeding beef cattle, especially young and growing animals.
(c) It is one of the best roughages for fattening lambs.
(d) It is excellent for wintering ewes and its use will result in strong lambs and a good supply of milk.
(e) It is appropriate for growing colts and brood mares, and some can be fed to working horses.
(f) The provision of alfalfa hay in feed racks for wintering brood sows is a valuable aid in getting good litters.

Alfalfa is increasingly popular. The average Canadian acreage for the years 1937-1941 was 991,000 acres and in 1943, there were 1,544,000 acres. A little more than half the alfalfa acreage of Canada in that latter year was in Ontario, while Manitoba had the second largest acreage and Alberta, third.

Alfalfa Meal. Alfalfa meal as sold in the trade is ground alfalfa hay and "it shall not contain more than 33% of crude fibre".

Alfalfa Leaf Meal is "chiefly ground alfalfa leaves, and shall contain not more than 18% of crude fibre". (*The Feeding Stuffs Act*).

Alsike. Perennial
Canadian Feed Unit Value of the Hay—0.53
Nutritive Ratio—1:4.7
Palatability—Very High

Alsike is grown principally in the more humid sections of Canada. It is suited to wet soil. It is not often seeded alone for pasture or hay but is an important item in many eastern mixtures. Animals grazing it have been known to develop soreness on the white parts of their bodies. Alsike starts growth early and offers grazing for a long season. It makes the best hay if cut when the plants are in full bloom. The hay is used more by sheepmen than by horsemen.

White Clover. Perennial
Canadian Feed Unit Value of the Hay—0.53
Nutritive Ratio—1:4.0
Palatability—Very High

This is a low growing clover with creeping stems which root readily. It does best on well drained but moist soils. It is not a heavy yielder of either pasture or hay but the quality is high and its most important use is in permanent pasture mixtures. It affords grazing for a long season from early spring.

Ladino is a strain of white clover which has higher productivity and has done well under irrigation. It has not stood up well to continuous and heavy grazing and it carries with it a danger of bloating similar to that which applies in the case of alfalfa.

Sweet Clover. Biennial
Canadian Feed Unit Value of Hay—0.49
Nutritive Ratio—1:3.6
Palatability of hay and pasture—medium

Sweet clover has much to offer in soil improvement and is widely used as a feed crop. It fits well into farm rotations. Like other legumes it is high in protein content but is less palatable than some of the other legumes. A good deal depends upon mode of growth in sweet clover; with rank growth which is quite common, the stems become woody and wasteful.

It is one of the most difficult crops to cure for hay and consequently it is used more for pasture. The young plants make very satisfactory pasture with less danger of bloat than is the case with alfalfa. When sweet clover pastures "get ahead" of the grazing animals, it is advisable to go over the field with the mower and cut the taller plants, leaving the stubble sufficiently high to ensure preservation of the buds from which new growth comes. The pasture has good carrying capacity, but it will be seen that the best results will follow where it is grazed close to its capacity. *Cumarin* which gives sweet clover its bitter taste is less abundant in the young plants.

Where sweet clover is marked for hay, it should be cut when the blooms are beginning to open or just before. It is a great mistake to allow the crop to become more mature. In view of the difficulty of curing sweet clover for hay, there are a number of advantages in cutting with a binder and making small stooks before stacking. One cannot afford to take risks with sweet clover spoiling because spoiled or moulded sweet clover can produce serious sickness and death in farm animals. Sweet clover hay or silage showing any degree of spoilage should be discarded be-

cause of this danger and no animals suspected of having eaten spoiled forage should be submitted to any operation such as castration or dehorning because of the danger of hemhorrage. Cumarin is believed to be involved in the poisonous properties of the spoiled feed.

Red Clover. Biennial
Canadian Feed Unit Value of Hay—0.58
Nutritive Ratio—1:5.3
Palatability—Very High

Red clover is an important feed crop in Eastern Canada. It is sometimes seeded alone for pasture or hay but more frequently found in mixtures with grass crops. Red clover and timothy are frequently seeded together, the rate of seeding being about 8 pounds of each per acre. Red clover does not withstand heavy pasturing particularly well, and there is some danger of bloating when cattle and sheep gorge on it or eat it when it is wet. For hay, it should be cut shortly after the plants have reached full bloom.

Annual Legumes.—Soybeans, vetch and field peas are suited to furnish forage quickly for feeding. All are palatable and any one could be seeded quite simply and grown successfully in combination with oats for green feed.

Dairy herd on pasture, Colony Farm, B.C.

CHAPTER X

GRASSES AND OTHER NON-LEGUMES FOR HAY AND PASTURE

Brome. Canadian Feed Unit Value of Hay—0.56
Nutritive Ratio—1:8.4
Palatability—Very High

Brome is now considered to be the most palatable of all domestic grasses. It is a long-lived perennial well suited to northern districts on account of hardiness. It is fairly resistant to drought. Growth starts early in the spring and continues until late in the fall. One of its weaknesses is the tendency to become sod-bound and decline in yield after three or four years. Productivity continues better if it is combined with some alfalfa or other legume. The old strains of brome were criticized on account of their persistency and creeping habits but the newer, non-creeping varieties are comparatively easy to control.

Hardiness and extreme palatability make brome a popular grass crop in many parts of Canada particularly for pasture.

Timothy. Canadian Feed Unit Value of the Hay—0.51
Nutritive Ratio—1:16.7
Palatability—High.

Timothy is grown extensively in sections of Canada where moisture conditions are favourable. It is an important hay crop in Eastern Canada but is not rated highly as a pasture. It is comparatively easy to secure a stand of timothy. Growth is rapid in the early part of the season.

The best hay is secured by cutting just before the plants bloom. The hay is regarded as the best for working horses but feeders of cattle and sheep prefer hays from other grasses.

Crested Wheat Grass. Canadian Feed Unit Value of the Hay—0.57
Nutritive Ratio—1:7.8
Palatability—Medium

This grass of Russian origin is a comparative new-comer in Canada but has quickly established itself in the drier sections of the mid-western provinces. It is extremely hardy and will

GRASSES AND OTHER NON-LEGUMES FOR HAY AND PASTURE

	Average Composition						Digestible Ingredients in 100 lb.			Total Digestible Nutrients
	Moisture %	Ash %	Fat %	Fibre %	Nitrogen Free Extract %	Crude Protein %	Fat	Carbo-hydrates	Crude Protein	
Brome hay	8.1	7.2	2.5	29.8	42.6	9.8	1.0	43.7	5.5	51.5
Timothy hay	10.8	4.6	2.7	31.1	44.9	5.9	1.1	44.3	2.8	49.6
Crested Wheat grass hay	9.6	5.9	2.3	28.1	44.7	9.4	1.0	43.2	5.8	51.3
Blue grass hay	11.5	5.6	2.9	30.8	40.6	8.6	1.2	43.0	4.8	50.5
Red Top hay	9.1	5.6	2.1	29.1	46.3	7.8	0.8	45.6	4.3	51.7
Slender Wheat grass hay	9.4	5.9	2.8	30.1	42.2	9.6	1.2	42.6	5.9	51.2
Prairie hay	6.9	7.2	3.2	29.9	44.8	8.0	1.3	45.1	4.5	52.5
Midland hay	8.4	8.2	2.4	30.3	43.8	6.9	0.8	41.5	3.4	46.7
Slough hay	11.1	6.6	2.0	30.4	43.2	6.7	0.7	41.0	3.0	45.6
Millet hay	9.8	6.6	2.8	28.0	45.1	7.7	1.1	44.2	4.4	51.1
Corn fodder	19.8	5.0	2.1	21.7	44.9	6.5	1.6	46.0	3.5	53.1
Oat hay (cut at milk stage)	9.7	6.1	3.1	25.8	46.3	9.0	1.9	42.0	5.8	52.1
Rye hay	8.2	5.4	2.3	35.2	40.9	8.0	1.2	40.1	3.5	46.3
Wheat hay	10.5	6.4	1.8	28.3	44.7	8.3	0.7	45.8	5.4	52.8
Russian thistle hay	9.9	13.4	1.7	23.1	37.7	14.2	...	...	...	..
Barley straw	12.3	6.5	1.8	35.8	39.4	4.2	0.6	40.2	1.0	42.6
Oat straw	9.1	6.4	2.3	36.0	41.0	5.2	0.7	38.2	1.8	41.6
Rye straw	7.3	3.8	1.2	39.5	44.7	3.5	0.4	38.9	0.7	40.5
Wheat straw	8.5	5.5	1.7	37.2	42.4	4.7	0.5	34.3	0.4	35.8
Wheat chaff	11.0	6.5	1.5	30.0	46.1	4.9		..	...	..
Green oats	76.9	1.9	0.9	7.0	10.2	3.1	0.6	10.4	2.3	14.1
Green bluegrass	68.6	2.8	1.3	8.3	15.0	4.0	0.7	14.3	2.5	18.4
Green corn	79.4	1.2	0.5	5.4	11.7	1.8	0.3	10.5	1.1	12.3

persist better than any other domestic grass under conditions of drought. It thrives on a wide range of soils and is of the greatest economic value in soil conservation and as a means of increased feed security.

Growth starts early in the spring. In periods of drought it becomes dormant but with favourable moisture conditions, it revives and continues to grow late into the fall. Early in the season, palatability is high but with the advance of maturity the stems become quite stiff and fibrous. Cows grazing on the young

Shorthorns grazing on crested wheat grass at a Dominion Experimental Farm

grass up to milking time will give tainted milk but this can be overcome by removing the cows from the grass two or three hours before milking.

For hay, crested wheat grass should be cut soon after heading and any great delay will result in a marked increase in fibre and decrease in palatability. The hay is better for horse feeding than for cattle and sheep.

Blue Grass. Canadian Feed Unit Value of the Hay—0.55
Nutritive Ratio—1:9.5
Palatability—High

Kentucky blue grass and Canadian blue grass have about the same feeding value although the former outyields the latter in most instances. Blue grass has creeping root-stocks and is an aggressive grower. The hay is a fine-stemmed product possessing good feeding quality but the yield is not heavy and it is considered better for pasture than hay. The grass is particularly good for inclusion in grazing mixtures for beef cattle.

Red Top. Canadian Feed Unit Value—0.56
Nutritive Ratio—1:11.0
Palatability—Medium

This grass is a hardy perennial, possessing creeping root-stocks. It is well suited to damp soils and tolerant to acidity. Red Top will find its place more in mixtures than in pure stands. It makes a better pasture than a hay but where kept for hay it should be cut when in bloom; if not cut at that stage, the quality of the hay will deteriorate rather rapidly.

Slender Wheat Grass. Canadian Feed Unit Value of the Hay—0.57
Nutritive Ratio—1:7.7
Palatability—Medium.

Slender wheat grass, also called western rye grass is a hardy, native, bunch grass. It is well suited to northern areas and is rated more highly as a hay than a pasture. As a hay it is a high yielder and to secure a good quality of roughage, cutting should be done within a few days after heading.

Orchard Grass. Palatability—Low to Medium

This is a bunch grass and because of its vigorous growth it is somewhat lacking in fineness and quality; but it does well in shaded places and for that reason is selected for planting in orchards. It has not been used to any extent in the prairie provinces but has been a part of many mixtures in the eastern provinces. For hay, the crop should be cut at commencement of bloom.

Meadow Fescue. Palatability—Medium

This is a tall growing grass, sometimes called English blue-grass. It is hardy but not high in drought resistance. In palatability and nutritive value it resembles orchard grass. It is a quick maturing grass but relatively short-lived as perennials go. Its chief use is in mixtures.

Perennial Rye

Perennial rye is a low-growing perennial, characterized by quick growth and comparatively short life. It is better for pasture than for hay and may find use in some Canadian mixtures. In palatability it would rate high.

Tall Oat Grass

Tall oat grass makes a satisfactory pasture grass and is a high yielder of hay. It grows as a bunch grass and, as a perennial, it does not have a long life. It is moderately resistant to drought and will accept a wide range of soil conditions. The result is that tall oat grass will find a place in mixtures. For hay, it is best to cut it at the commencement of bloom. Its palatability rating would be "Low to Medium".

Reed Canary Grass

This is a sod grass which spreads by short root-stocks. It is a northern grass, capable of withstanding flooding and also moderate drought. It has a medium rating for palatability.

Johnson Grass

This is a coarse grass with a creeping root. It grows vigorously in the wild state in the south but is considered poor pasture and only mediocre for hay.

Sudan Grass

This is a coarse growing grass which has given enormous yields under irrigation. But it requires a lot of heat. To furnish temporary pasture in Eastern Canada it might be seeded in late May or early June, at about 25 pounds of seed per acre. Stunted or frozen Sudan grass may be a source of danger and should not be pastured.

Native Prairie Hay. Canadian Feed Unit Value—0.56
Nutritive Ratio—1:10.7
Palatability—High

The native upland hay of the western prairies, called "prairie wool" represents a mixture of grass species. The yield is generally low but the quality is high. These prairie grasses retain substantial feeding value even at maturity and are often cut late in the season or used to good advantage for fall and winter grazing. Owing to the low yield, it is the practice on many of the native upland meadows to cut for hay only every second year. Consequently there will be considerable "old bottom" in the hay which detracts from its feeding value. Rose bushes and other native weeds will also reduce the value of native hay.

Some important species entering into prairie hay are

Spear grass (Stipa comata)
Grama grass (Bouteloua gracilis)
Western wheat grass or bluejoint (Agropyron smithii)
June grass (Koeleria cristata)
Sandberg's bluegrass (Poa secunda)
Upland meadow grass (Poe buckleyana)
Nigger wool (Carex filifolia)

Midland Hay. Canadian Feed Unit Value—0.44
Nutritive Ratio—1:12.7
Palatability—Medium

Midland hay is a flat land product, about intermediate between prairie hay and slough hay in palatability and feeding value.

Slough Hay. Canadian Feed Unit Value—0.37
Nutritive Ratio—1:14.2
Palatability—Poor

This is an extremely variable product and its exact value will depend upon the species, the texture, and the stage at which it is cut. Where the hay is coarse and cut late, its feeding value is little better than that of oat straw. The sedges which are frequently present in sloughs are poorer for feed than the grasses. Some common species of grasses and sedges present in slough hay follow:

Grasses—

Tall manna grass (Gyceria grandis)
Nerved manna grass (Gyceria striata)
Spangle top (Fluminia festucacea)
Slough grass (Beckmannia Syzigachne)
Northern reed grass (Calamagrostis inexpansa)
Fowl blue grass (Poa palustris)
Slender alkali grass (Puccinellia tenuiflora)
Alkali grass (Distichlis dentata)

Sedges and Bulrushes—

Awned sedge (Carex atherodes)
Water sedge (Carex aquatilis)
Prairie bulrush (Scirpus paludosus)
Great bulrush (Scirpus validus)
Spike rush (Eleocharis palustris)

Millet. Canadian Feed Unit Value of Hay—0.53
Nutritive Ratio—1:10.6
Palatability—Medium

Millet is a quick growing annual, sometimes planted as a catch crop and used for hay. Its palatability is not high and as a hay it is considered better for cattle than for horses. The foxtail type makes the best forage. Seeded in early June, it could be pastured in six weeks but it has never been a favourite as a pasture crop.

Fodder Corn. Canadian Feed Unit Value—0.57
Nutritive Ratio—1:14.2
Palatability—High

The seeded acreage of fodder corn in Canada in 1943 was 475,000 acres of which 307,000 acres were in Ontario. It does not lend itself to storing in stack or mow and consequently it is commonly left in the stook in the field until ready to be used. It is not as acceptable to live-stock as corn silage but is a fair substitute and highly palatable. Its best use is for cattle and sheep.

The Cereals for Pasture and Hay

In Mid-Western Canada, the cereals are employed quite commonly for annual forage. The seed is comparatively cheap and easy to plant, and it germinates readily. Oats and beardless barley are two favourites for summer pasture or for "green feed" in sheaf form but wheat and rye are used also. A mixture of 1½ bushels of oats and 1½ bushels of barley per acre seeded together gives very satisfactory summer pasture for pigs and other classes of stock.

Rye seeded in early August at the rate of two bushels of seed per acre will furnish temporary pasture in fall and early spring months. Unless care is exercised to remove the stock two or three hours before milking however, cows grazing on this pasture will give tainted milk.

Oat Hay. Canadian Feed Unit Value—0.56
Nutritive Ratio—1:8.0
Palatability—Medium

Oat hay cut with the binder and fed in the sheaf is by far the most commonly used of the cereal hays. When cut in the milk stage or early dough stage, the roughage is quite palatable and useful for general feeding. For feeding cattle, sheep and horses, however, it is better if some grass hay or legume hay can be fed along with the oat sheaves. Sheep growers have suspected that oat sheaves fed as the sole roughage to wintering ewes have resulted in poorer lambing records.

Wheat hay cut early is about as satisfactory as oat hay but not so palatable. Rye hay is low in palatability especially if not

cut early. Hay from the bearded varieties of barley is objectionable on account of the danger of causing sore mouths and abscessed jaws.

"Cover Crop"

Cover crops which are now proving a big aid in fattening cattle in parts of Alberta, had a beginning as a measure to prevent soil drifting. Autumn grazing privileges on the cover crops of cereal grains sold in the earlier years of its use at 50 cents per head per month with salt and water included. In recent years the acreage of cover crops has been extended and its popularity as a feed for fall fattening of cattle may be judged from the fact that the grazing rental was $4.50 to $7.00 per acre in 1944. Gains in fattening cattle have been high and there has been interest in extending the cover crop area; but unless more suitable crops can be found or produced, extension of cover crop use will be limited to areas with fairly good precipitation.

The Cereal Straws

	C.F.U. Value	*Nutritive Ratio*
Barley Straw	0.32	1:41.6
Oat Straw	0.29	1:22.1
Rye Straw	0.20	1:56.9
Wheat Straw	0.19	1:88.6

The straws represent a fibrous part of the cereal plants after much of the most valuable feed material has been removed in the seeds. Consequently they are low in net feeding value but can sometimes be combined with better roughages with some economic advantage. Barley straw has the best feeding value but in the case of the rough awned varieties, the danger of injury to the consuming animals is sufficient to make the straw definitely objectionable. With the beardless and smooth awned types, this hazard is overcome and the straw might be used to good advantage in maintenance rations for beef cattle, sheep and horses. Oat straw is almost on a par with barley straw while wheat straw and rye straw should not be considered for feeding except under emergency circumstances.

Two points of importance are to be noted about feeding cereal straws; first, that a good deal depends upon the greeness of the crop at cutting time and second, that animals which run at a straw pile or have the chance to pick over a lot of straw will reject the least desirable portions and do much better than those animals fed limited allowances of straw in their mangers.

Rape

Rape belongs to the turnip family but the leaves are more palatable and more nutritious than those of the turnip. It is at its best as a fall pasture for pigs and sheep and is not considered for hay. It is customary to plant rape in drills 28 inches apart, cultivate between the rows during summer and start grazing in the early fall. The early fall frosts tend to sweeten the leaves and animals will find it a most attractive feed at a time when most other crops have become dry. Cattle and sheep may bloat readily if permitted to gorge themselves on rape, or if the rape is damp.

There is no better fall pasture for pigs and when precautions are taken to reduce the danger of bloat, it is excellent for fattening lambs and flushing ewes.

Russian Thistle

As an emergency feed in the drier sections of the mid-western provinces, the Russian thistle has served a useful purpose. The species has an interesting history, having been introduced in flax seed brought from Russia to South Dakota in 1873. In a comparatively short time its seed became spread over a large section of the Great Plains. It thrives in dry years when there is little competition from other plants and no plants having value in Canadian agriculture can produce a pound of dry matter on less moisture. This is partly accounted for by the absence of typical leaves and the low evaporation.

In analysis, these weeds are relatively high in protein and extremely high in mineral ash, especially in the early stages of growth. That high ash content accounts for the tendency to scouring in animals eating it. It cannot be recommended for pasture purposes.

As maturity advances beyond the bloom stage, there is a marked reduction in ash content, some reduction in protein content, an increase in fat and fibre and little change in nitrogen-free extract.

Russian thistles have not been satisfactory for silage. The silage undergoes extreme heating and becomes dark and foul smelling. Its best use is as hay. For this purpose, it should be cut before the spines harden. Very early cutting makes curing difficult and gives a high concentration of salts, while late cutting means high fibre and sharp spines.

The hay gives the best return in roughage mixtures and it has been surprising how well cattle and sheep have survived on mixtures of Russian thistles and cereal straw. The Russian thistles should not comprise over 50% with straw or grass hay and here is a case where processing by means of a hammer-mill to overcome the spiney nature of the thistles will be an advantage.

Mixtures for Hay and Pasture

Mixtures containing grasses and legumes have certain advantages, among them the following:

(1) The grazing season can be extended.
(2) Greater variety stimulates appetite.
(3) A mixture provides better nutritional balance.
(4) The legumes like alfalfa will be safer for pasture when mixed with grasses.
(5) A combination of a legume and a grass will often outyield either crop grown by itself. (Tests in Finland showed that inoculated legumes can excrete nitrogen compounds from the nodules, thereby enriching other crops being grown in the mixture.)
(6) The roots penetrate to different depths, making more complete use of the land.

Two Ontario recommendations for mixtures are:

Where Alfalfa does well		*Where alfalfa does not do well*	
Alfalfa	6 lb.	Red clover	8 lb.
Red clover	4 lb.	Alsike clover	2 lb.
Alsike clover	2 lb.	Ladino clover	1 lb.
Ladino clover	1 lb.	White clover	1 lb.
White clover	1 lb.	Timothy	6 lb.
Timothy	4 lb.	Orchard grass	2 lb.
Orchard grass	2 lb.		
Seed per acre	20 lb.	Seed per acre	20 lb.

Timothy and red clover make a popular and widely used combination in Eastern Canada.

In sections of Western Canada, the brome and alfalfa combination has been especially good, giving high yields of hay and excellent balance for feeding. Twelve pounds of brome seed and two to four pounds of alfalfa seed per acre have been used. In the drier sections of the mid-western provinces, crested wheat grass and alfalfa or crested wheat grass and sweet clover have been favoured.

Yield tests conducted by the Dominion Forage Laboratory at Saskatoon show something of the advantages which can be claimed for these grass-legume combinations under dry-land, prairie conditions. In the test for which yield figures follow, the plots were cut three times each season to simulate pasturing and the yields are given in pounds of air-dried hay.

Cattle drinking from a "Dug-out" in Southern Alberta

	Average yield per acre 1938-42
Brome grass alone	1,349 lb.
Brome grass plus Grimm alfalfa	3,726 lb.
Brome grass plus Ladak alfalfa	3,201 lb.
Fairway crested wheat grass alone	1,584 lb.
Fairway crested wheat plus Grimm alfalfa	4,060 lb.
Fairway crested wheat plus Ladak alfalfa	3,409 lb.

Annual Forage Mixtures

Annual legumes, such as vetch and field peas, are sometimes needed in conjunction with oats to furnish a quick-growing forage. Some recommendations from the Ontario Agricultural College are:

(a) ½ bushel common vetch and 1½ bushels of oats per acre, seeded together.
(b) 1 bushel of field peas and 1½ bushels of oats per acre.
(c) 1½ bushels of soy beans and 15 pounds of early foxtail millet per acre.

Another suggestion for a quick growing temporary pasture and one which could be used widely consists of 2 bushels of oats and 15 pounds of sweet clover seeded together about late May. With favourable growing conditions, this would supply a serviceable pasture after five or six weeks.

CHAPTER XI

INFERIOR AND HARMFUL FEEDS

It is just as important that the stockman be familiar with the feeds that are inferior or definitely injurious as it is that he know the feeds most nutritious and healthful. Of the inferior feeds, there are those which have been leached by rains or allowed to become too mature, with the result that there is but little of feeding value left. Wheat straw carrying little more than fibre is an example, and so is mature legume hay from which the leaves have been lost. Hay which has been exposed to a series of rains, totalling 2 inches, may lose 25% of its dry matter; the fibre remains while the proteins, nitrogen-free extract, fat and mineral matter suffer heavy loss. Under such circumstances, the protein may be lost to the extent of 50%

In addition to those feeds which are classified as "inferior", there is a group that is distinctly injurious and therefore of the utmost importance, to wit, ergot in rye, spoiled sweet clover, poisonous plants and feeds from which prussic acid poisoning may arise.

Contrary to some opinions, rusted roughages and smutted grains are not injurious to a marked degree, and roughage feeds like grass hay or oat sheaves which have undergone mild heating in the stack are not necessarily harmful. Heated or mouldy feeds are always less nutritious however because the process of heating inevitably involves oxidation and thus the consumption of food materials, usually the most readily available. Heat generated in a stack or bin means that something is being burned and unfortunately, it is usually the best part of the feed that is consumed. Heated or musty feed is usually dusty and the dust may be particularly obnoxious to the horse and cause coughing. Horses are probably more susceptible to injury from the eating of spoiled feed than are other classes of farm animals. It is of the utmost practical importance that everything possible be done to prevent spoiling in feeds.

Pigs which were fed experimentally on barley which was extremely smutted showed no evidence of toxity or injury. This was also true when smut dust and smut balls were added to make a 10% concentration of smut in the feed. Gains were

lower than those to be expected from sound grains but there was no evidence of specific injury and the conclusion seemed justified that stockmen need have no fear of using cereal grains which carry a moderate amount of smut.

Rust. The discovery of rust resistant varieties of grains made the problems of utilizing rusted crops and rusted straw of much less importance than in former years. It was commonly thought that rusted straw had a mildly toxic effect, but investigation conducted at the University of Saskatchewan revealed no support for that theory. It was shown that the levels of nitrogen-free extract, fat and mineral material were about the same for rusted and clean straws while the protein content of the rusted straw averaged 6.98% compared to 5.59% for the clean straws. In feeding trials in which lambs were forced to eat substantial amounts of rust dust gathered from binders and threshing machines, no ill effects were noted and no sign of trouble was detected when the visceral organs were examined at the time of slaughter. The study seemed to warrant the conclusion that rusted straw was little better or little worse than the rust-free straw.

Spoiled Sweet Clover. Spoiled sweet clover has accounted for deaths in cattle and other live-stock and the best advice is to discard all sweet clover hay or silage that shows mould or any degree of spoiling. It is believed that a decomposition product of cumarin in the sweet clover is the substance which causes injury. Where spoiled sweet clover is fed the blood loses its clotting power and thus internal hemhorrages or minor external injuries have serious consequences. Although the exact nature of that sweet clover disease is not understood, stockmen are warned not to perform operations like dehorning or castrating while the animals' rations include sweet clover. The plant breeders will score another triumph when they develop satisfactory strains of cumarin-free sweet clover; such strains will not only be less hazardous in the event of spoiling but more palatable as well.

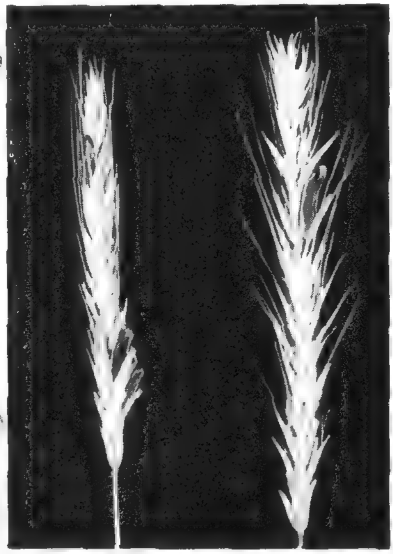
Damaged Flax

Prussic acid poisoning may not give the stockman much warning so he should be familiar with the possible sources of such trouble. It has been known to occur when frozen or immature flax was fed, also from the feeding of dwarfed sorghum. It is always safer to feed flaxseed jelly rather than the raw flaxseed to pail-fed calves, especially if the flaxseed is not sound and mature, because the boiling or heating destroys the enzyme which might otherwise hydrolyze the glucoside from which the prussic acid arises.

Ergot

A farmer had 18 cows and several mares abort in one month before he learned of the injurious effects of ergot which occurs very frequently in rye and less frequently in barley, wheat and some native grasses. Ergot is a plant fungus (*Claviceps purpurea*) and the purplish black ergot bodies found in the threshed rye grain are larger than the healthy rye kernels. They are called *sclerotia*. The active substance in the ergot bodies affects the uterus and abortion is a common result. It may be of some interest in passing, to note that the organism is sometimes cultivated artificially for use in medicine, and may be used to check

Showing a severe infestation of ergot on rye



Ergot bodies may be seen on these heads of rye

hemorrhage or to stimulate the walls of the uterus during parturition. Continued consumption of ergot-infested feed may produce a condition called ergotism in which the extremities of the body, ears, tail and perhaps feet, develop a dry and painful gangrene.

Ergot poisoning has occurred in man in various parts of the world, especially where rye bread is a prominent part of the diet. In Russia, rye flour containing 0.15% of ergot was observed to cause ergotism. In live-stock feeding, what seemed a very small concentration of ergot has produced trouble. Cattle and

horses are most susceptible to its injurious effects. Apart altogether from the poisonous properties, feeds affected by ergot are likely to possess somewhat reduced feeding value.

The best advice to the feeder, therefore, is to exclude completely if possible, ergotized material from the rations. Such a policy is particularly important in the cases of mares, cows, sows and ewes. Judging from what information is available, any grain feed which contains 0.1% or more of ergot material must be regarded as a definite source of danger. Where farmers are faced with the problem of finding a use for contaminated feeds, they may be willing to assume some little risk. In any case, as much of the ergot material as possible should be removed by means of a fanning mill. After that, the concentration of ergot can be further reduced by mixing the offending feed with disease-free feed. Such a mixture might be fed cautiously to fattening animals. As a matter of fact, since ergot occurs most commonly in rye, a grain which ranks low in palatability, mixing rye with other grains may be resorted to as a matter of course.

Potato Poison

The majority of feeders are unaware of a potential danger which lurks in the common potato. It is on account of the alkaloid called *solanin* which may be in a comparatively concentrated state in the skins, potato sprouts, green potatoes, frozen potatoes or the water in which the unpeeled potatoes were cooked. Even potato tops may carry sufficient solanin to represent a possible danger.

Poison Plants

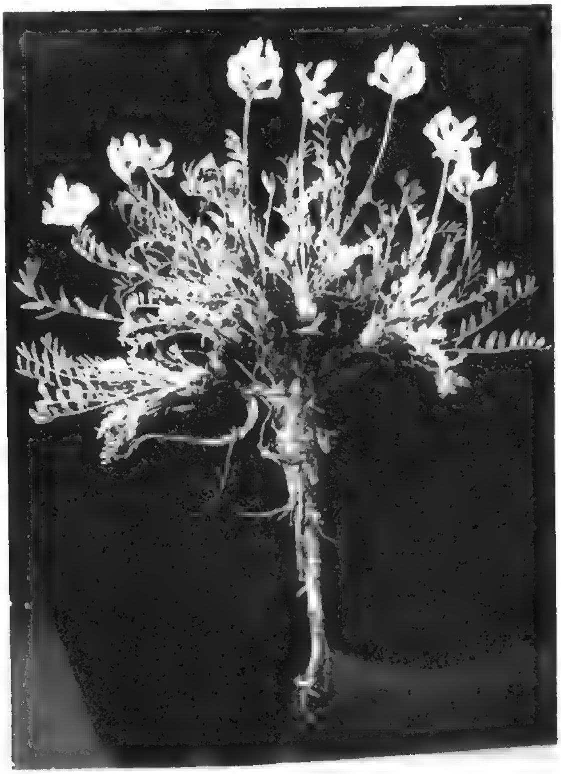
From some sections of both United States and Canada have come reports of *selenium* poisoning in animals. Affected animals were said to have "blind staggers" or alkali disease. Selenium is one of the rare elements and highly toxic. Certain plants growing on certain soils will accumulate sufficient selenium to cause injury or death to the animals eating the forage. Some of the native prairie legumes including narrow-leaved milk vetch (*Cnemidophacos pectinatus*) and two-grooved milk vetch (*Diholcos bisulcatus*), are offenders. Their growth has been taken to indicate a seleniferous area.

Of the native plants which are known to possess poisonous qualities, there are loco weed, water hemlock, death camas, horsetail, seaside arrowgrass and larkspur. Probably there are more. The ostensibly innocent native crocus has been suspected but when crocuses were fed to white rats and experimental sheep at the University of Saskatchewan there were no deaths and no evident disorders. Chokecherry leaves have been known to

poison lambs, presumably through the formation in the stomach of prussic acid. The stockman would do well to know those plants which are harmful and be ready to eradicate them if necessary.

Loco Weed

More than average interest is attached to the loco weed because of the peculiar behaviour of the animals that become its victims. The plant is a long-lived perennial and the danger of poisoning is centred in the crown of the root. Cattle do not graze sufficiently closely to reach the root but horses and sheep



Loco Weed, one of the poisonous native plants

grazing on short pastures may get it. Apparently the drug present is habit-forming because the victims soon begin looking for it and the unsteady gait and irresponsible behaviour of the animals suggest intoxication or mental derangement.

Feeds Producing Taint in Milk and Meat

Feeds which impart an objectionable taint or odour to milk, butter and meat, must surely be classified as harmful. French weed or stink weed is very objectionable in pastures where milking cows graze. Turnips, rape, green rye and crested wheat grass are also capable of imparting a disagreeable flavour to the milk but this can be overcome if the milking cows are removed from the pasture or feed, some two, three or four hours before milking. Turnips, when fed, should be given after milking rather than before.

Beef, pork and mutton from animals that consumed substantial amounts of green French weed or French weed seed prior to slaughter, are sometimes most unpalatable, to the point where the average person will refuse to eat any of the meat. Feeders were told that rations to fattening animals should contain no French weed seed for at least two or better still, three weeks prior to slaughtering. But when fattening lambs at the University of Saskatchewan were forced to eat grain rations comprising 50% of French weed seed it was found that one week on clean feed was sufficient to completely rid the meat of the objectionable flavour.

CHAPTER XII

PROCESSING FEEDS

Processing means (1) chaffing and grinding roughage
(2) grinding and rolling grain
(3) soaking
(4) cooking

It usually represents an effort to make the feed more palatable, more digestible or more economical. In every case however, there is a cost for power, fuel or time and feeders should consider that cost in relation to advantages. Needless processing represents extravagance and feeders should determine if the net advantage in processing exceeds the cost. In the corn belt of the United States, for example, one may hear that grinding corn for cattle increases the value of the grain slightly but not enough to compensate for labour and fuel used in doing the work; consequently much of the corn is fed whole.

Chaffing and Grinding Roughage. Chaffing roughage by means of a cutting-box, or grinding roughage with a hammer or other type of mill, has certain advantages:

(1) Chaffing or grinding roughage will reduce waste by making it difficult for the animals to pick over the feed and reject part of it.

(2) Processing makes it possible to mix feeds more thoroughly. For example, hay and oat straw would be difficult to mix in the uncut state but can be blended easily when cut or ground.

(3) In the case of an emergency feed like Russian thistles, grinding will break the spines and thus make the feed less objectionable to the stock.

The net advantage in processing will depend upon the degree to which the above are applicable, but one should not overlook the costs and also the fact that grinding roughage does not increase digestibility; fine grinding may actually reduce digestibility of the fibre. The above noted advantages for processing roughage can be gained by the use of a cutting-box or chaffer which can be operated more quickly and more cheaply than those mills which grind to a finer state.

In a feeding test at the University of Saskatchewan, four groups of fattening calves received ordinary roughage feeds prepared in different ways; lot one received uncut roughage; lot two received finely ground roughage from a hammer-type mill; lot three received medium ground roughage from a combination-type mill and lot four received coarsely chaffed roughage from a cutting box. The same kind and quality of roughage was used with each group. Some of the conclusions drawn from that experiment will be of general interest and make a much stronger case for the cutting box and chaffed roughage than for a mill which tends to powder the feed. Here are some of the comments and conclusions arising from the experiment:

"(1) The greatest amount of waste is to be expected when long roughage is fed."

"(2) If such waste could be controlled by specially equipped mangers and feed racks, it would seem that processing of roughage is of doubtful value."

"(3) The very fine grinding of roughage tends to lower its palatability."

"(4) The need for continuous access to water is increased when cattle are eating finely ground feeds."

"(5) Remastication is materially reduced when finely ground roughage is fed."

"(6) In rates of gain and total gains for lots in the experiment, the differences were barely significant."

"(7) The cattle receiving the chaffed roughage showed a substantial saving in cost of feed required to make a unit of gain."

"(8) When the cost of processing the roughage was included for all groups, the saving in cost of gains was still more favourable for Lot four (chaffed roughage)."

"(9) There was no difference in quality of finish or quality of carcass."

"(10) From this experiment it would appear that there is no advantage in grinding roughage to a very fine state for fattening calves."

Grinding or Rolling Grain. To facilitate the work of the digestive juices, feed in the form of hard seeds must be broken by mastication or some other means. Farm animals with sound teeth can perform the necessary work effectively and can grind their feed more economically than would be possible with mechanical power.. The trouble is that the common farm grains are small and hard and may quite easily escape mastication with the

result that there is loss in feed. In addition, some animals "bolt" their grain or fail to masticate properly on account of faulty teeth. Horses and pigs are more inclined to "bolt" their grain feed than cattle or sheep. Sheep make the most thorough job of mastication.

Notwithstanding the economy with which normal farm animals can do their own grinding, practical considerations make grinding, rolling or crushing of grain advisable. In addition to increasing the digestibility of the grains, such processing will help to destroy the germinating power of the seeds, weed seeds and others. Clean oats need not be processed for sheep but the harder grains like barley or wheat are better to be cracked or ground coarsely for this class of stock. Medium grinding of grain is best for cattle. Many old horsemen preferred to feed whole rather than crushed oats to horses, claiming that the natural grains gave additional stamina. This theory is no longer accepted and present day horsemen choose rolled or crushed oats.

In trials at the University of Saskatchewan, it was shown that grinding barley to a medium state of fineness increased its feeding value for pigs by 16%. It is considered best to grind all grains for pigs, wheat to a coarse state; barley, medium; and oats, fine.

Soaking. Where grains cannot be ground for pigs, there is some advantage in soaking them for a period of 36 to 48 hours. The seeds will soften and swell and be less likely to escape mastication.

The soaking of ground grains has shown no special advantage but the policy of feeding those ground grains in a wet or moistened state to pigs seems justified. The pigs seem to relish the moistened or wet feed more than they do the dry feed and if feeding is performed outside, there will be less loss from wind if the meal is moistened.

Cooking. Under most circumstances, cooking of feeds for farm animals does not justify the cost of fuel and labour. There are a few exceptions however; potatoes and beans will be much better for pigs if cooked and those who are anxious to fatten beef cattle or horses quickly for show or sale, will find special merit in boiled barley. Boiled barley with some bran and a little salt is a favourite feed with cattle showmen. The barley for cooking need not be ground and it should be remembered that cooking will also destroy the germinating power of the seeds.

CHAPTER XIII

FEED RESERVES

Any plan for sound and enduring diversification in agriculture presupposes an optimum balance between cropland, grassland, feed reserves and live-stock. Expansion in live-stock production, to be on solid footing, must be supported by reasonably certain feed supplies; it is not inappropriate that agriculturalists remind themselves that unless adequate precautions are taken, an inflated population of live-stock, built up during a period of favourable crop years, could make farming people more vulnerable to the disasters of drought and feed failure.

This has greatest application in the Mid-Western provinces where climatic extremes are more common than in the East. Westerners will not soon forget 1937 when crop failure forced a wholesale liquidation of breeding stock and brought disaster to many herds and flocks. It was a disaster which might have been eased a good deal by feed reserves on the farms. But years of drought in those Mid-Western provinces were not confined to the '30's; a review of rainfall and crop records in Western Canada for a 50-year period shows a strange mixture of "good" and "bad" years, years of plenty and years of drought and failure. There are farmers on the prairies who remember very clearly the hundreds of blazing straw piles which lit up the autumn nights following the super abundance of 1915 and 1916, and also the trying experience of having to pay $40.00 a ton for baled straw in 1919.

Feed reserves will increase the live-stock grower's security and consolidate his position. Something can be done by well planned cropping practices and by setting aside quantities of those feeds which lend themselves to storage without serious deterioration.

Feed Grains. A reserve of feed grains is entirely practicable and can do much to help stabilize production, pig production in particular. The success of a "carry over" plan with such feed depends entirely upon the dryness of the grain when it is placed in storage and the adequacy of the storage bin. The bin must be able to turn the rain; and it will be much better if mouse-proof and closed to birds.

Grains which have heated or moulded, or grains which are "tough" and in danger of spoiling should not be marked for "carry-over". Whole grains will keep better than ground or crushed grains; this point is one of importance in all grains but it bears particular importance in seeds having a high content of oil, e.g. corn, flax, soybeans. Non-oily feeds are best for storage.

Roughage Feeds. Roughage feeds, not usually as salable as the grains, are most likely to be used in a security plan intended to remove some of the risks in feeding cattle, sheep and horses. In some instances, farmers will decide to establish reserves of silage. Where a good silo is available, and care is used in preparation of the feed, the silage product will keep for a number of years. Corn silage, cereal silage or legume silage mixed with molasses or ground grain to increase the carbohydrate content, would be suitable. The trench silo represents a practical means of accommodating extra roughage feed, and when the silage is likely to be kept for more than a year, the trench silo has certain advantages over one of upright type.

But in most cases, the roughage reservoir will include hay and straw. Oat sheaves are not favoured for "carry over" purposes as they usually lose a good deal in palatability and feeding value, unless storage conditions are exceptionally good. Oat sheaves held over summer in stacks, will become very dry and brittle in the straw and are likely to suffer serious loss through the ravages of mice. Something can be done to retard damage from mice by sprinkling each layer of sheaves as placed in the stack with a little sulphur, using in all about one pound of sulphur to a load or ton of sheaves. On the farm where there is a surplus of oat sheaves and hay, the best policy would be to feed mainly oat sheaves at first and mark a bigger portion of the hay for reserve.

Hay Reserves. When grass hay, wild or domestic, is placed in a mow in good condition, it will keep for years without serious deterioration. The same is true of hay placed in carefully made stacks in the drier sections of Western Canada. Cattlemen in the ranch country have discovered that grass hay in big and well-topped stacks is one of the best forms of insurance against failure, and visitors in South-Western Saskatchewan and Southern Alberta may see stacks of "prairie wool" which are 6 or 8 years old and still good except for discolouration and deterioration on the outside. Young folk who love to climb and play on stacks can so disrupt the "top" that it will no longer turn the rain and severe spoilage may be the result.

Cut or chaffed hay will store in greatly reduced space as compared with the uncut hay, but its keeping qualities will be reduced by the processing. There is greater danger of heating in the processed roughage and it will lose palatability more quickly. Baling hay for long storage is a better plan than cutting, but the hay for baling must be dry or spoiling will certainly occur.

It should be recognized that hay which has lost its rich green colour has lost most of its vitamin A value, but where hay has been protected against weathering, the other feed constituents are not likely to alter much. The possibility of vitamin A deficiency should not be forgotten however, where old hay is in use.

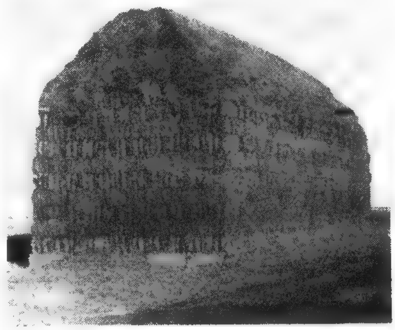
What is stated about hay in these paragraphs is largely true for straw. Where stook threshing is practised in the fields, all

A supply of roughage feeds in well made stacks

possible care should be exercised to ensure well-built stacks. Symmetrical stacks with extra height will have the best keeping qualities. The old time thresherman took a good deal of pride in the shape and height of his stacks and built to "turn the weather".

Grassland Conservation. Conservation of native grassland and an extension of domestic grass acreage where it is appropriate, constitute an important challenge and could help a good deal to increase security where live-stock are kept. Reserve pastures organized on a Community Pasture basis will prove of great benefit in years of severe drought.

Mention should be made in this chapter about feeds and feed products which should not be kept for long periods. As already pointed out, feeds rich in fat or oil will become rancid in time. Supplements such as tankage and fish meal and concentrates containing tankage or other products of animal origin should not be kept for long periods. If spoiling occurs in such feed products, it may prove very dangerous to the health of animals. Some other feed products may lose value without any change in appearance; for example, iodized salt unless the iodine is combined with a dependable stabilizer, will lose its iodine potency, and fish liver oil unless held in a closed container will lose vitamin A. Mixed feeds to which fish oil is added for the purpose of increasing vitamin A content, are likely to lose much of the advantage in the course of weeks.



Stack of baled hay erected at Gravelbourg as a feed reserve in 1939

But chief concern is with the broader issues and all who have anything to do with farm planning should remember that climatic variations will result in fluctuations in feed grain and roughage supplies. Feed reserves can effectively relieve the shock of the poor years. Pasture reserves can be set up on a community basis but in grain and hay conservation, the individual farmers can do much for themselves.

PART III

NUTRITION AND THE PRACTICE OF FEEDING

CHAPTER XIV

CHARACTERISTICS OF A DESIRABLE RATION

Technically, a ration refers to the amount and kind of feed furnished to an animal in a period of twenty-four hours. The best rations for farm animals will possess the following specifications and characteristics:

(1) Optimum bulk or dry matter.
(2) Adequate net energy for maintenance and production.
(3) Adequate protein, mineral matter and vitamins.
(4) Palatability.
(5) Safety and healthful tendencies.
(6) Capacity to meet special needs of animals being fed.
(7) Variety.
(8) Reasonable economy.

Optimum Bulk or Dry Matter. The necessary food nutrients in terms of fuel energy, protein, etc., might be furnished to cattle or horses or sheep, in concentrated form and yet be quite unsatisfactory for animal welfare. A certain optimum degree of fullness in stomach and intestines is necessary to proper digestion, normal peristalsis and evacuation. Too much bulk can also create trouble; distention can cause severe indigestion and animals fed on bulky rations of low net feeding value may be unable to obtain enough digested feed nutrients to meet the body requirements.

Consequently, the reliable feeding standard states a certain minimum and maximum weight of dry matter for animals of specified size. Dairy cows require between 20 and 30 pounds of dry matter daily per 1,000 pounds of live weight; wintering ewes should get between 2.2 pounds and 2.5 pounds of dry matter daily per 100 pounds of live weight. Pigs are adapted to more concentrated rations and for sows in pig, the dry matter range is stated as 1.4 pounds to 2.0 pounds daily.

Adequate Net Energy. The net energy represents the fuel supply with which the animal can maintain body functions and perform special work. In ordinary farm feeding, carbohydrate material

is the most economical source of energy, but a calorie is a specified unit of heat or energy irrespective of whether it originates with the burning of carbohydrates, fats or proteins. If, on account of insufficient feed, low quality of feed or poor digestibility, the net return from a ration is inadequate for the energy needs, an animal must call upon its own body reserves and tissues. On the other hand, a surplus over and above the needs for maintenance and special work will go to form fat in the body.

The feeding standards state energy requirements of farm animals in terms of Canadian Feed Units, Total Digestible Nutrients or Calories or Therms of Energy. Obviously working animals will have a much higher requirement than those on maintenance when body temperature and physiological activity represent the main charges against the feed. Rations of average quality if fed in sufficient amounts will nearly always support maintenance but for working, milking or fattening stock, richer rations will be needed.

Adequate for Protein, Mineral Matter and Vitamins. Here it is simply a matter of ensuring that a ration contain adequate amounts of all the materials necessary to do a stated job, whether it is maintenance, physical work, milk production, reproduction or something else. Probably the most common weaknesses in Canadian rations are deficiencies in protein, mineral matter, or vitamins.

The addition of protein material when the feed is low in that constituent results in more complete utilization of the energy in the entire ration. Thus attention to this phase of ration balancing will result in a return much greater than the productive energy of the actual protein added and thus will make for more complete use of feeds.

Palatability. Digestion will be more thorough and the general response will be better if the ration is palatable. In the case of cows in heavy milk, fattening animals or any stock being fed for high production, it is especially important that rations be appetizing. It is well known that the flow of digestive juices is retarded where the feed is distasteful.

The low palatability of rye grain is the main reason for its unpopularity with feeders. Chemical analysis gives rye a high value but stock-men are convinced that its full value is not secured in actual feeding. Grass pasture, corn silage, linseed oil meal and bran are highly palatable and consequently they improve rations in which they are included.

Safety and Healthful Tendencies. There is a definite relationship between palatability and healthful qualities in rations.

Animals will eat with more vigour and be less likely to go "off feed" or develop digestive troubles where the ration is palatable. Where unpalatable or damaged feeds must be used, they should be mixed in small proportion with other and better feeds.

Capacity to Meet Special Needs. Milking dairy cows need a certain amount of fat in their rations and a minimum of 3% or 4% in the grain feed is suggested. Similarly, in pig rations, it is important that the fibre content be kept low.

Variety. Animals will have keener appetites and utilize their feed better when there is variety in the rations. They tire of a feed, just as people tire of having the same food day after day. Furthermore, since feeds vary in quality, there is less likelihood of nutritional deficiency where a range of feeds is included in a ration. Mixed feeds are especially important in meeting the protein needs of pigs, because a single source of protein may not furnish all the amino acids required by the growing animal.

Reasonable Economy. The most practical and profitable rations are those kept at a low cost in relation to the result.

Feed represents half or more of the cost of producing meat and milk. Good breeding of the animals and more care in rationing represent the main hopes in reducing cost of production. A wider range of home-grown feeds would be a major aid in achieving better rations economically. The legume hays are examples; alfalfa in particular is high in protein and calcium and, if carefully cured, is a good source of vitamins A and D. Alfalfa hay is a cheaper source of these "balancers" in live-stock rations than the commercial feeds which are often bought to furnish them.

CHAPTER XV

PIG NUTRITION

Both the pig and the man who feeds the pig belong to that group of animals which thrives on mixed diets. The lowly rat also belongs to this group. Their digestive tracts, their physiological demands and their instinctive appetites make a strictly herbivorous or carnivorous diet inappropriate. They are omnivorous creatures and require foods of both vegetable and animal origin.

In pig nutrition, quality of diet assumes new significance and it becomes clear that there are many ways of starving a pig. Beside the time-honoured empty-trough method of inducing death, it is known now that starvation in some degree can be caused by a deficiency of iodine in prenatal life, a deficiency of iron during the nursing period, a deficiency of calcium, phosphorus, or any one of a series of vitamins at some other period, or a bad balance between the muscle-building and the fuel-supplying parts of the feed.

It does seem that the pig is more vulnerable to one form or another of starvation than most of the other animals about the farm, the human included. The most probable reason is that a pig grows very quickly and therefore requires the various building materials at a faster rate. The average human being begins this life at a weight of seven or eight pounds and it will be twenty-five years or more before he reaches a weight of two hundred pounds, while any self respecting modern pig, with a birth weight of just under three pounds, will attain two hundred pounds in six months. The bigger the burden of production in pig or cow or other animal, the more vulnerable it is to nutritional "crack-up".

The basis of pig rations is cereal grains. That is as it should be, but grains alone will not supply all the ingredients necessary to produce a pig any more than flour by itself will make doughnuts. Nor will lumber by itself be sufficient to build a house; cement, gravel, bricks, nails, paper and fixtures are required. The starchy grains and water will be sufficient to keep "steam up" in the pig, but to achieve growth or other forms of production, other materials must be supplied. Under conditions of domesti-

cation, some of the feed substances must be provided in supplemental form. In constructing good rations for pigs, the appropriate materials will be drawn from the following tabulated lists:

- Pig Rations
  - Grains
    - Barley
    - Wheat
    - Oats
    - Corn
    - Rye
    - Certain Mill Feeds
    - Combinations of these form basis of rations and are major sources of energy.
  - Supplements
    - Protein Supplements (one of which is needed in all pig rations)
      - Skim milk
      - Buttermilk
      - Tankage
      - Fish Meal
      - Mixed Concentrate (40% Protein)
    - Mineral Supplements
      - Salt for all pigs.
      - Ground limestone when ration is otherwise low in lime.
      - Iron sulphate for suckling pigs on board or cement floors.
      - Potassium Iodide for pregnant sows.
    - Vitamins
      - "A" Anti-infection factor, supplied by green forage and fish liver oil.
      - "B complex" provided adequately in most home grown rations.
      - "D" Sunshine factor, supplied by sunshine or fish liver oil.
    - Succulent Feed—(Green forage in summer and roots when available in winter.)
  - Water

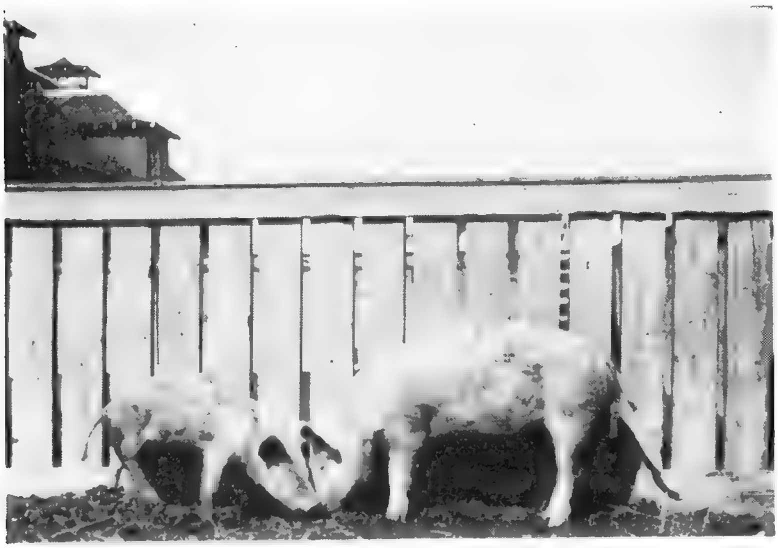
The Common Grains

Barley. Farm grown grains, mainly barley, wheat and oats, will constitute the basis of nearly all pig rations. Corn, rye and recleaned screenings will find limited use, but barley is likely to remain a favourite with Canadian producers. It is low in fibre, palatable, and in most cases an economical feed. Considered over a period of years, barley has represented a cheaper source of digestible nutrients or Canadian Feed Units than any other

feed for pigs. When correctly supplemented, barley is capable of promoting growth efficiently and yielding good carcasses. Of the single grains it is generally considered the most suitable for pigs.

The farmers of the U.S.A. have supposed that no grain can equal corn for pigs but there is convincing evidence that both barley and wheat are as good or better and capable of yielding superior carcasses.

Wheat. Canada's capacity for wheat production is enormous and the export market for wheat seems uncertain. It may be that wheat will find ever wider use as a feed; it is not impossible



Litter mates—the difference was accounted for by nutrition. The smaller pig is suffering from rickets.

that it will be grown mainly for feeding in some sections, in much the same manner as American farmers grow corn. There are areas in the prairie provinces where a farmer can produce more pounds of pork per acre from wheat than would be possible from other grains. There is still some unjustifiable prejudice against wheat as a pig feed; experimentation over a period of years has produced results that should dispel most of the "hand-me-down" superstitions about the feeding qualities of this grain.

Pigs have been raised with a fair measure of success on rations composed of wheat and supplements, but no other grain.

There has been a tendency however for the carcasses from wheat-fed pigs to be over-fat, due to the palatability and high feeding value of wheat or perhaps to some other rather specific characteristic in the grain. In the interests of good carcasses then, it may be advisable to restrict the wheat in pig rations, feeding it preferably with a small proportion of oats or a larger proportion of barley.

Notwithstanding these words of caution, wheat will find wide use in pig feeding when its price is favourable. For feeding purposes, the lower grades will be more economical than, and almost as good as, the milling grades. One of the main practical

Grand Champion Yorkshire boar at the Canadian National Exhibition, Toronto, 1940

points to remember in rationing wheat to pigs or other live-stock is that a gallon of wheat chop may nearly double a gallon of oat chop in weight and when wheat is fed from the "gallon measure" rather than by weight, overfeeding is more likely to occur. Wheat should be ground to a medium state of fineness for pigs.

Rye grain has an analysis rather like that of wheat but it is not relished by pigs and not popular among pig growers. It can however, be utilized when mixed with other grains.

Oats. The value of the grain for pigs has been exaggerated. Because oats are an excellent feed for horses, some folk believe they must be good for pigs. It doesn't follow; the horse can digest the fibrous part of the oat grain and the pig cannot. Ordinary oats have, roughly, 28% of hull and 11% of fibre; therefore many pig rations would be better and more economical if they carried less oats and more barley or wheat. Still oats have a place in pig rationing; there is no better grain feed for weanling pigs than sifted oat chop (hulls removed) and ordinary oat chop may find limited use along with barley or wheat for older pigs and sows.

The Problem of Fibre. The digestive apparatus of the pig simply cannot break down for use in the body, more than the slightest amount of fibre, perhaps 2%. The leafy portions of the legume hays have considerable supplementary value but, the common roughages on account of fibre content, are practically worthless. The same is true of oat hulls; oat hulls may be useful in rations for sheep and cattle and horses, but when fed in abundance to pigs, they represent a nigh-starvation diet.

A high percentage of fibre is distinctly detrimental in a pig ration. Rate and economy of gain will usually bear an inverse relationship to the percentage of fibre in the feed, as the following data from a Saskatchewan trial will show:

	Ration	*Fibre in Ration*	*Av. Daily Gain*	*Feed Consumed per 100 pounds gain*
Pen 1	Hulless Barley and Tankage	2.9%	1.3 lb.	355 lb.
Pen 2	Common Barley and Tankage	4.9%	1.25 lb.	372 lb.
Pen 3	Oats and Tankage	10.6%	0.9 lb.	454 lb.
Pen 4	Hulless Barley and Oat Hulls and Tankage	11.4%	0.8 lb.	450 lb.

Six per cent of fibre should be the maximum allowed in rations for growing and fattening pigs and eleven per cent in the rations of brood sows.

Protein Supplements. The common grains are relatively low in protein, and the proteins present do not possess the quality, or the range of amino acids, needed to support rapid and economical growth. In balancing pig rations, therefore, it is a primary essential that optimum amounts of protein material of suitable kind be incorporated with the grains. Since proteins vary in constitution, it is difficult to state requirements in exact figures.

Quality of protein is much more important in pig rations than

in cattle rations because pigs lack the ability to reform protein material by synthesizing amino acids or protein "building stones". Thus the protein "building stones" needed by the pig to nourish its body and construct new tissue must be provided in the feed. Proteins of animal origin furnish a wider range of amino acids needed to construct protein material in the pig's body and are therefore most suitable.

Skim Milk and Buttermilk. It is a point of cardinal importance in pig nutrition that skim milk, buttermilk, tankage, fish meal or a mixture in which the animal proteins are prominent, is far

Grand Champion Yorkshire sow at the Canadian National Exhibition, Toronto, 1940

superior to any protein supplement of vegetable origin or combination of vegetable supplements. There is no better protein supplement than skim milk or buttermilk and the grower who has one of these, possesses a distinct advantage in producing healthy pigs economically. On the basis of protein content alone, buttermilk should have a value of 18 cents per 100 pounds when 50% protein tankage sells for $50 per ton.

Tankage and Fish Meal. But skim milk or buttermilk is not always available and the "next best" single product is tankage

or meat meal or fish meal. Tankage is an all-meat by-product from the packing houses and fish meal comes from fish waste and discard fish. Tankage varies in protein content but commonly contains about 50%. The non-oily fish meal is highly regarded in many sections of Eastern Canada and on the Pacific coast, but in inland areas, its high price is likely to restrict its use except in mixtures where a small percentage is considered very important.

Mixed Protein Concentrates. If one will purchase or take the trouble to prepare a mixed concentrate of reliable kind, the feeding results will surpass those from fish meal or tankage used

A convenient wagon for use in feeding pigs

singly as a supplement. A mixture which illustrates the principle and has been employed with most encouraging results is composed of:

40	parts of tankage by weight
15	parts of fish meal
20	parts of linseed oil meal
10	parts of alfalfa meal
10	parts of common salt
5	parts of ground limestone
100	

Protein-mineral concentrates constituted more or less as the above are being manufactured and sold widely in Canada. When this commercial product carries a protein content of about 40%

and contains at least 35% or 40% of animal matter such as tankage and fish meal, it will undoubtedly give good results. Concentrates meeting these specifications and sold by reliable feed manufacturers in Canada have achieved justifiable popularity. Most farmers will conclude that it is just as economical and certainly more convenient to purchase these mixed supplements instead of preparing them. Feed manufacturers have a big advantage because of automatic or mechanical mixers which turn out a uniform product. Uniformity of mixture is most difficult to obtain by hand or shovel methods.

Farmers must assess for themselves the net value of other substances placed in protein-mineral supplements. Some ingredients like stabilized iodine and vitamin D, would be definitely beneficial while some other materials may be quite valueless, and others like unstabilized iodine and vitamin A, may not remain in the mixture long enough to be useful.

Quick Growth is Important. Rapid gains are usually associated with economical gains and it is generally considered good practice to bring commercial animals to market weight quickly. But in addition, it has been shown recently by British workers, and confirmed elsewhere, that the ultimate muscle development of a bacon pig is pretty well determined in early life and feeders should insist upon liberal and careful feeding at least up to the time the pig is four months old. The worst type of bacon carcass is from a pig which has been poorly fed or stunted in early life and is later fed heavily with the object of fattening quickly. This produces the undesirable thick back-fat. In other words, rapid growth in early life or before the pig reaches 100 pounds, is conducive to the highest percentage of lean meat in the ultimate bacon carcass. After the pig has reached 100 pounds, the rate of growth and fattening may be permitted to slow down somewhat. The policy followed on many farms is quite the opposite, slow growth early and full feeding after 125 or 150 pounds. It is a matter of extreme importance to the Canadian bacon trade, then, that good rations, high levels of protein, and quick growth in early life are assured in pig production. Overfinish and underfinish, two common criticisms of Canadian bacon sides, are due very largely to improper feeding.

Feeders should not be satisfied with an average gain of less than one pound per day between weaning time and the one hundred pound stage. If gains are less than that, it probably reflects insufficient feed, improper balance or unthriftiness on account of parasites or disease.

Nothing in the experimental records has changed the view that young pigs require the highest level of protein; therefore

for weanling pigs, 2 to 2½ pounds of skim milk or buttermilk per pound of grain, or 10% to 14% of mixed concentrate should be provided. As pigs become older, the proportion of supplement may be dropped gradually. The amount of protein matter supplied to pregnant and nursing sows is important too. Protein stimulates milk production as the dairymen know, and in tests conducted in recent years, a fair level of protein supplement fed to pregnant sows resulted in heavier pigs at weaning time.

Mineral Supplements for Pigs. There has been a lot of loose talk about mineral feeds and considerable money has been wasted on them. Tons of the material have been fed needlessly and tons of it have not been fed when needed. It should be provided to fit

Tamworth boar imported to Canada by Al. Greenway in 1944

the need. About 4% of the pig is mineral matter or ash and most, but not all, is in the bones. Of the particular elements not supplied in the ordinary course of feeding, there are only four about which the pig feeder need have much concern; common salt, lime, iron and iodine.

Common salt should be supplied to all pigs at all seasons, although one half of one per cent seems entirely adequate in spite of certain recommendations that more be fed. Of the bone building elements, the pig needs lime or calcium more than phosphorus, because the pig eats the plant seeds, thus getting most of the plant phosphorus. Growing pigs and pregnant and nurs-

ing sows not getting a good share of milk or tankage, are most likely to need the extra lime. Ground limestone of high calcium content is recommended and can be incorporated with the grain at the rate of ½ pound of limestone to 100 pounds of grain.

Potassium iodide supplied to pregnant sows and some extra iron in the form of iron sulphate to suckling pigs confined to inside pens will reduce losses. The amounts to be fed are given later.

Vitamins. Stockmen and others are becoming vitamin conscious, but apart from vitamins A and D, it is unlikely that pig diets constituted with a fair amount of variety will be noticeably vitamin short. The farm grains are likely to supply the "B" factors adequately, although pig pellagra resulting from a deficiency of *niacin* has been recognized. Pigs do not take scurvy and therefore vitamin C is not a limiting factor.

But pig-men must think about vitamins A and D. Vitamin A which is essential to growth, reproduction and health, is abundant in green forage and in certain fish liver oils. Its influence in making the linings of the respiratory tract more resistant to bacterial attack may be very significant and it is sometimes called the anti-infection vitamin. A lot of winter rations are definitely deficient in vitamin A, and should be supplemented.

Vitamin D, called the sunshine factor, is essential to the utilization of calcium and phosphorus. There will be no lack of this in the summer months but from November to March when animals are more or less confined and the sun is comparatively ineffective, there is need for a supplement. There aren't many black pigs left in Canada, since the Yorkshire has become virtually the national breed, but it will be of interest to pig growers to know that white pigs are better than black ones for storing vitamin D, and are thus less likely to develop rickets when deprived of sunshine.

A reliable or tested fish liver oil will furnish both vitamins A and D and should be provided for young pigs during winter months. It is not to be regarded as a medicine; it is in all respects a feed, and an essential feed. Progressive pig men regard an allowance of fish liver oil daily to young pigs, perhaps one-half ounce per pig per day of an oil testing 1,500 A, 200 D, just as important as the provision of salt.

Water. Pigs should have all the water they want. Skim milk or buttermilk in a ration will reduce the need but still the pigs should be permitted to take what extra liquid they want. Pigs are more affected by alkali water than are cattle, sheep and horses and where there is an alternative, water high in alkali salts should be avoided.

Needless Ingredients. Feeders should strive to provide those substances which are needed and to avoid materials which are useless or harmful. There is no proof of the need for extra copper, manganese, sulphur, zinc, potassium and magnesium, and no proof of need for extra iron except in the case of suckling pigs under certain circumstances. Nor is there much of a case to be made for laxatives such as Glauber's salts, condition powders, flavouring materials and many worm remedies. Health and efficient production are not achieved that way and such products are not commonly a part of good nutrition or good management.

Green Forage. As pigs are omnivorous they should not be expected to subsist entirely upon pasture. Nevertheless the use of pasture or green forage carried to the pigs will save a good deal of grain and contribute to their health. Under the most favourable pasture conditions, it is possible for dry sows to maintain themselves without grain feed but, in a general way, the green forage should not be expected to replace more than one-third or one-half of the grain in the ration, one-third in the case of growing pigs and one-half for dry sows.

For pigs destined for market, the fastest gains can be achieved by carrying green forage to them in their small pens, but with breeding stock, the pasture method will be most practicable. In a trial conducted at the University of Saskatchewan three pens of pigs were fed as follows:

Pen 1, Full grain ration with protein supplement, fed in inside pen.

Pen 2, $\frac{2}{3}$ full grain ration with protein supplement and green forage carried to inside pen.

Pen 3, $\frac{2}{3}$ full grain ration with protein supplement, on pasture.

The average rate of gain in these pens was 1.35 pounds, 1.28 pounds and 1.16 pounds respectively and the grain consumption per 100 pounds of gain was 322 pounds, 232 pounds and 259 pounds respectively.

In any case it is a big mistake to allow growing pigs to run in large pasture fields. Losses due to excessive exercise will counteract much of the advantage from the green forage. Permanent pastures, such as alfalfa, have many advantages but one serious disadvantage; they are liable to become contaminated with the eggs of parasites such as the common round worm. Permanent pastures may be satisfactory for dry sows but for young and growing pigs, annual pastures on land which is rotated or ploughed each year will be safer.

Green forages in the immature state are high in protein,

low in fibre and rich in vitamins and minerals, and all these features add to their value. Alfalfa stands in first position among permanent pastures and of the annual pastures, wheat, oats and barley afford good summer grazing. Rape fills a big need for fall pasture, and it is at its best after most other crops are finished.

Summer shelter is most important for pigs on pasture. Sunburn which can cause severe setback is most serious when pigs are exposed to hot summer sun after being wet.

CHAPTER XVI

THE PRACTICE OF FEEDING PIGS

The amount and kind of feed which should be provided for any animal will depend upon the animal's requirements. Pigs at different ages and performing different physiological tasks require different rations in point of quantity and quality. Careful attention to rationing will pay good dividends in quicker growth and more economical gains, while lack of care will prove costly.

Feeding Boars. Young boars should be given feeds which will stimulate growth of bone and muscle. Protein and mineral supplements should be fed generously. It is a mistake to allow boars to become either very fat or very thin; a medium degree of fatness is best for activity and efficiency in breeding. A pasture paddock with shade will provide the best quarters during the summer months, and in winter, the pigs should be comfortably housed and allowed some exercise.

Specimen rations suggested for boars past four months of age follow:

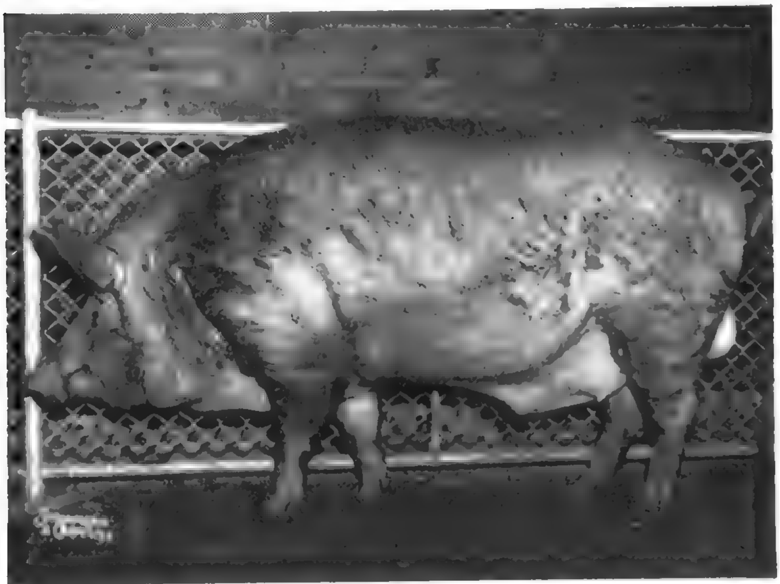
Ration Number	*Grain*	*Protein Supplement*	*Other Supplements*
I	Equal parts ground wheat and oats	1½ lb. skim milk or buttermilk per lb. of grain *or* 5% to 6% of protein-mineral mixed supplement	Green forage in summer and an allowance of roots and/or good alfalfa hay in winter. Salt at all seasons
II	Equal parts shorts and ground barley	ditto	ditto
III	Two parts ground barley and one part ground oats	ditto	ditto

The importance of some green forage during summer months and an allowance of leafy alfalfa hay during winter cannot be stressed too strongly. Besides those supplements mentioned, a little fish liver oil might be beneficial during winter.

Moderation in feeding the boar is important and he should be

given only that amount of feed which he will eat readily. Except for the first few weeks after weaning, two feeds a day are sufficient.

In some cases where inadequate nutrition has been suspected as the cause of breeding failure in a boar, or when it was desired to "pep up" the ration, a supplement of raw liver has given dramatic results. Liver is known to be a storehouse for numerous food factors, and the suggestion has been to give the slow or unthrifty boar, a daily allowance of one pound of liver from a healthy animal daily for two or three weeks.



Courtesy Ontario Live Stock Branch

Grand Champion Tamworth Boar, Royal Winter Fair 1937, owned by Charles B. Baynton, Gormley, Ontario

Feeding Brood Sows. The sow's performance as a breeder depends largely upon the feed and care she receives. Vigorous and well-grown gilts make the best sows. Gilts require a slightly higher percentage of protein material and more feed per hundred pounds of live weight, but otherwise feeding practices are about the same for gilts and sows. It is a mistake to allow either gilts or sows to become very fat, and in order to prevent excessive fatness, it may be necessary at times to restrict the grain or use feed which is more bulky than straight barley or wheat.

Some combination of barley and oats, or wheat and oats furnishes the best basis.

Mature sows are in the best condition for breeding when rather thin but gaining in flesh. Consistent with the practice of "flushing" in sheep, those sows which are gaining in condition at the time of breeding will produce and release more eggs and would thus be expected to farrow bigger litters. Sows on good pasture and receiving from one-half to two-thirds of full grain ration plus supplements, should be in good condition for breeding.

For pregnant sows, rations should include grain, protein supplement, alfalfa, salt, lime and iodine. Grain feed will vary, but it is suggested that a grain mixture containing 35% to 50% ground oats with the balance comprising any combination of ground barley and wheat, will give good general results. It is not possible to be exact about amounts of grain to feed because young sows should be fed more liberally than old ones, and thin sows need more feed than fat ones. Mature sows on the average should get about one pound of grain per 100 pounds of live weight during early pregnancy and 25% more during the last month. Gilts should have about 1½ pounds of grain per 100 pounds liveweight.

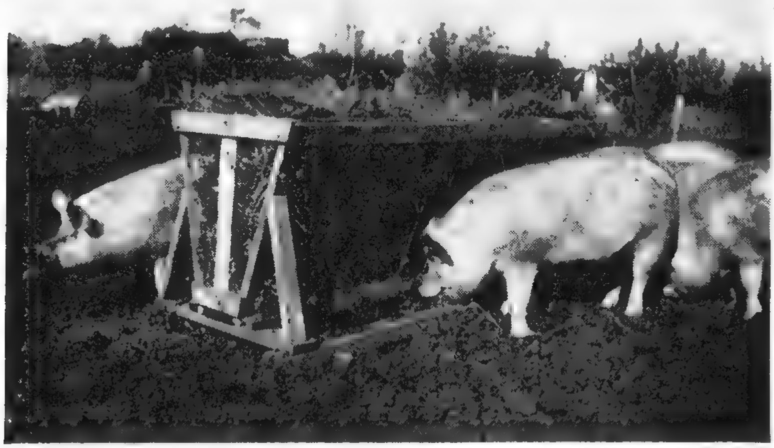
Supplements for Pregnant Sows. There is increasing evidence of the advantages of fortifying sows by means of protein, calcium, vitamin A, and perhaps other food factors during pregnancy. Stronger litters and a better milk supply and heavier pigs at weaning time are the rewards of thoughtful rationing. One pound of skim milk or buttermilk per pound of grain or 5% of a reliable mixed concentrate carrying 40% protein is recommended, with an increase to 6% as farrowing approaches. In a controlled trial, sows which had received 6% of tankage through pregnancy, weaned more pigs and pigs heavier by 4.5 pounds than sows which had been on 4% of tankage.

There is reason to believe that the rather wide-spread occurrence of milk failure in sows in recent years is associated with inadequate rations, particularly a lack of calcium, a shortage of protein material, or vitamin A deficiency.

If the milk or protein-mineral supplement given the bred sow is limited, provision should be made for extra calcium. One half of one percent of a good grade of ground limestone added to grain fed is sufficient; and to ensure its utilization, and at the same time provide additional vitamin A for body welfare, an allowance of one to two teaspoonfuls of a fish liver oil testing 1,500 A, 200 D, is recommended. For six consecutive years, the lime-supplemented sows in an experimental herd farrowing in the spring, proved more certain milkers and gave about 25 pounds additional weight of pigs at weaning time, than sows

not getting the lime. A small forkful of alfalfa hay thrown to the sows each day during winter months would be most beneficial. The hay form is preferable to the alfalfa meal because it permits the sows to eat the leafy and choicer parts and reject the fibrous portions. Variety is always important, which may account for the fact that the sow which enjoys the freedom of the farm yard usually has a good farrowing record.

Iodine to Prevent Hairless Litters. Hairless pigs are the direct result of insufficient iodine and it is a reasonable precaution in nearly all parts of Canada to supply some potassium iodide to all breeding females, especially during winter months. The pig breeder is advised to dissolve an ounce of potassium iodide in



An alfalfa rack built for breeding gilts and sows

one gallon of soft water, keep the solution in a stoppered jar or crock, and allow each sow a tablespoonful on her feed two or three times a week during the latter half of pregnancy. The period of pregnancy in sows is 114 days.

Feeding Orphan Pigs. When the sow's milk fails or where there is a litter larger than the sow can accommodate, some young pigs may have to be raised as orphans or transferred to another sow. If a transfer is made, it should be before the foster mother has been farrowed for more than a few days; otherwise the extra mammary glands will cease to function. In raising young pigs by hand it is customary to use a bottle with a nipple on it for the

first days at least. The milk should be from one cow only and should not be diluted or changed unless the young pigs start scouring, in which case the milk might be diluted temporarily with about one-third of lime water. For the first few days, a daily allowance of five to seven ounces of milk per pig will be enough. It is most important to feed the young pigs often, at least eight times per day, and not much at a time. The milk should be clean and at blood heat. A few drops of cod liver oil or other fish liver oil in the milk given to each pig daily will help. The customary precautions should be taken to prevent anaemia and when the young animals are ten days old they should be encouraged to take some feed consisting of sifted oat chop (hulls removed) and milk from a trough.

The Nursing Sow. To ensure a laxative condition at farrowing, a part of the regular grain ration could be replaced with bran. At farrowing time the sow should have a thoroughly clean pen, equipped with a guard rail and correctly bedded. After farrowing, the ration should be increased gradually and also the proportion of protein supplement to support milk secretion.

Oats, barley, wheat and shorts in one combination or another are suitable for milking sows. The following are ration suggestions:

Ration Number	*Meal Combinations Suggested*	*Protein supplement*
I	1 part barley 1 part oats 1 part wheat	For each grain mixture listed feed two pounds of skim milk per pound of meal
II	2 parts oats 2 parts wheat 1 part shorts	*or*
III	1 part barley or wheat 1 part oats	8% to 10% of tankage or mixed protein concentrate

How much grain or meal feed should be given to a milking sow? A good rule is to allow the sow a pound of grain feed daily for each pig she is nursing, with a minimum of eight pounds. That would mean ten pounds to the sow feeding ten pigs and twelve pounds daily to the sow with twelve pigs.

Some green forage, roots or alfalfa hay should be placed before the milking sow daily and during the fall or winter or early spring the allowance of fish liver oil should be continued because depletion of bone material during lactation weakens the skeleton of some sows to such an extent that there is danger of fractures in the vertebrae or leg bones.

Iron for Suckling Pigs. If anemia is to be prevented in suckling pigs which are confined to pens during winter or early spring, steps must be taken to supply supplemental iron. Nature made no provision for the iron requirements of those young animals being reared on board or cement floors and sow's milk is no help, even though iron compounds are fed to the sow. Pigs running outside root in the earth and get the iron needed.

Therefore, the producer who is raising winter or early spring pigs must choose between:

(a) catching each young pig periodically and placing a little reduced iron in its mouth; or

(b) painting iron sulphate solution on the sow's udder daily, or

(c) placing a shovelful of dirt sods in the pen daily for the young pigs to root in; or

(d) placing sods in the pen daily and sprinkling them with two or three tablespoonfuls of a solution made by dissolving six ounces of iron sulphate in a gallon of water.

The main thing is to get a little iron into the young pig, and experience has shown that the treated sods offer the most convenient method. The provision of these sods should continue from the time the young pigs are a week old until weaning.

Creep Feeding. Creep feeding before weaning consists of placing a little low-fibre meal where the suckling pigs can get it. Usually a hurdle equipped with a small opening, can be placed across the corner of the pen in such a way that only the young pigs can pass through to the special feed. Sifted oat chop is ideal and may be fed with or without a protein supplement; if milk is used to moisten the meal, the trough must be cleaned out regularly. Creep feeding has a definite advantage and will result in heavier pigs at weaning time and less setback in the adjustments which must be made at that period.

Weanling Pigs. The young pigs which have had plenty of milk and which have been protected from parasitic and disease infection should weigh 30 pounds each at 8 weeks, which is a common weaning age. Male pigs not needed for breeding should be castrated before weaning time.

The transfer from sow's milk to weanling rations can give the young pig a serious jolt and therefore, weanling pigs must have special attention. Whether they are to be reared for breeding or market, they need low-fibre rations, rich in protein and bone-building material. A commercial pig-starter may be used or an 18% home-prepared protein ration, bearing the same general

characteristics; such a high-protein pig-starter is of special importance where pigs are weaned at less than seven weeks of age.

There is no better grain for starting young pigs than sifted oat chop (hulls removed); shorts is an alternative and wheat is also satisfactory. Whatever grain is chosen, the protein supplement must be provided generously, and about 12% of mixed concentrate or tankage or fish meal is the alternative to skim milk or buttermilk at two to two and one half pounds per pound of grain fed. The young pigs will feed better if there are not too many in a pen and the quarters are comfortable.

Tetany. Tetany, which is characterized by convulsive fits when the pigs are aroused at feeding time, has been too common in the period shortly after weaning. It is a warning that the calcium-phosphorus balance is all wrong due to factors to be explained. The preventive treatment is a higher intake of lime during that period after weaning and the remedy is practically the same, ground limestone and vitamin D, or lime water and vitamin D.

Feeding Market Pigs. Rations supporting quick growth are usually most profitable. They should be adapted to the changing needs as pigs advance from weaning time to market weight. The principle changes should be consistent with the following facts:

(a) The young pigs need the highest level of protein.
(b) Total feed consumption increases with increasing size, but feed consumption per unit of body weight decreases.
(c) Rapid gains in early life result in leaner and better bacon carcasses.
(d) A slightly higher percentage of fibre can be taken as the pig develops.
(e) The younger pigs need the most attention in point of vitamin supplements, notably vitamins A and D, and it is especially important that they receive a winter supplement of tested fish liver oil until they reach 100 pounds at least.

Grain and Protein Requirements of Growing and Fattening Pigs

Weight of Pigs	*Grain as Barley (lb. to be fed per day)*	*Recommended level of Protein in total ration*
Weanlings to 50 lb.	1.75 to 2.75 lb.	17%
50 to 100 lb.	2.75 to 4.5 lb.	16%
100 to 150 lb.	4.5 to 6.0 lb.	15%
150 to 200 lb.	6.0 to 7.5 lb.	13%

Ration Suggestions for Growing and Fattening Pigs

Weight of Pigs	*Alternative Grain Rations*	*Alternative Protein Supplements and Amounts to be fed with the Grain (one only to be fed)*		
		Skim milk or butter-milk with each 100 lb. grain	*Tankage or Fish meal to be mixed with grain*	*Mixed Protein mineral concentrate to be mixed with grain*
Suckling Pigs (Creep Feeding)	A. Sifted Oat Chop	—	—	—
	B. Medium Ground Wheat	—	—	—
Weanlings to 50 pounds	A. Sifted Oat Chop	200 lb.	10% to 12%	10% to 14%
	B. {2 parts barley or wheat, 1 part shorts}	200 lb.	10% to 12%	10% to 14%
50 to 100 pounds	A. Barley and Wheat Mixture	150 lb.	9%	9%
	B. {2 parts barley or wheat, 1 part oats}	150 lb.	9%	9%
100 to 150 pounds	A. Barley and Wheat Mixture	100 lb.	6%	6%
	B. {3 parts barley or wheat, 1 part oats}	100 lb.	6%	6%
150 to 200 pounds	A. Barley and Wheat Mixture	50 lb.	3%	3%
	B. {3 parts barley or wheat, 1 part oats}	50 lb.	3%	3%

In the feed recommendations made here, it should be noted that the principle ration differences with advancing weight and age are in protein levels. In this instance the protein in the ration has been reduced gradually from 17% or 18% in the weanling ration to 14% for the period prior to market. The nature of the grain feeds is changed but little after the pigs reach 50 pounds. Salt should, of course, be provided at all times and green roughage or roots whenever possible.

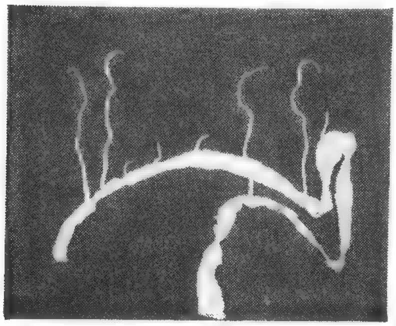
When thrifty pigs have good rations, the grain consumption to make 100 pounds of gain in weight will be found to approximate the following:

Weaning to 50 pounds—275 pounds of grain.
50 to 100 pounds—300 pounds of grain.
100 to 150 pounds—350 pounds of grain.
150 to 200 pounds—400 pounds of grain.

The Self Feeder. The self feeder is essentially a labour saver and is more suitable for market pigs than breeding stock. Its use will produce maximum gains but the grain requirement per unit of gain in weight will run 10% to 15% higher than where careful hand feeding is practised. Barley and wheat should be tempered with oats for use from the self feeder; otherwise over-finish is more apt to occur.

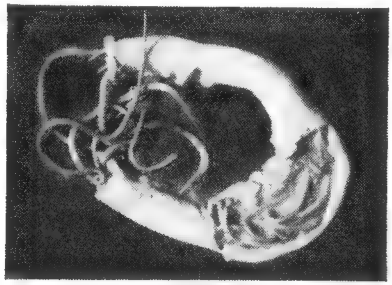
When hand feeding is practised, it is recommended that pigs under 100 pounds be fed three times daily, and all others twice daily. The aim is to feed only what the pigs will clean up in 15 or 20 minutes.

Two Hundred Pounds at Six Months. Pigs which do not reach 200 pounds at six months of age, have been handicapped by



Courtesy Ontario Live Stock Branch

Thorn headed worms in pig's intestine



Courtesy Ontario Live Stock Branch

Section of pig's intestine filled with round worms

hereditary slow growth, parasites or disease, or, inadequate feeding. Barrows gain slightly faster than gilts but gilts, on the average, yield superior carcasses.

Experiments with bacon pigs show that full feeding from weaning to the 100 pounds stage results in the best carcasses whereas limited feeding in early stages causes injury which cannot be overcome by full feeding from 100 pounds to market weight.

Preparation of Feeds. All grains should be ground for pigs but very fine grinding is needless and uneconomical. Soaking feed avails nothing except where whole grains rather than ground grains must be fed; in which case it is better to soak grains such as barley or wheat for from 36 to 48 hours. The practice of cooking feeds is of doubtful value except in the case of potatoes

and beans. Garbage when fed to pigs should be cooked for sanitary reasons. While the soaking of ground grains is difficult to justify, many pig feeders do feed the ground grains in a moist or wet state. There are no well-defined advantages for or against wet feeding as compared with dry feeding, unless it is that pigs relish the moistened feed more.

How Would the Pig Balance its Ration? There is good reason to believe that an animal's instinctive appetite is a good indication of its nutritional needs. At least it is reassuring when pigs given a wide choice, balance their rations in a manner consistent with modern recommendations. In a series of free-choice trials conducted by the author, pigs gained 1.54 pounds daily and averaged 218 pounds at 190 days. The pigs had access to grain, tankage, fish meal, salt, limestone, bone meal, soil treated with iron sulphate and untreated soil. Relative to grain consumed, the tankage and fish meal eaten were 5.6% and 2.7% respectively. The total of 8.3% of protein supplement to grain is a higher average than commonly recommended for the entire feeding period, but may be close to the level required for maximum growth. It was significant that the percentage rate of intake for those protein supplements was much higher in the early part of the feeding period.

The voluntary consumption of ground limestone was at one-quarter of one per cent of the grain consumption, and the salt taken was even less than this. Admittedly there is some salt and calcium in tankage and fish meal. The greatest appetite for soil was during the first few weeks after weaning, and the consumption of soil treated with iron was 50% greater than that of untreated soil.

Chapter XVII

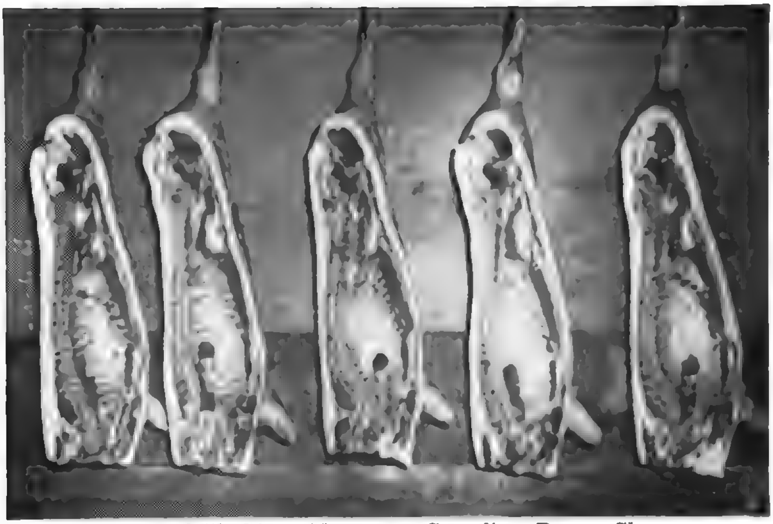
PORK PRODUCTION COSTS IN TERMS OF BARLEY

To say that 350 or 400 pounds of grain will produce 100 pounds of gain in feed-lot pigs is to tell but part of the story about costs because it does not account for supplements, losses, overhead and feed consumed by the parent stock, all chargeable to the pigs that are sold. In the course of the study reported herewith, an attempt was made to convert all production costs to terms of barley or barley equivalent. Skim milk or buttermilk, used as a protein supplement, for example, was assumed to have one-fifth the value of barley, pound for pound. Pasture is capable of being a valuable aid in pig production but as growers make use of it in varying degrees, in this experimental study, feeding was conducted in the absence of pasture.

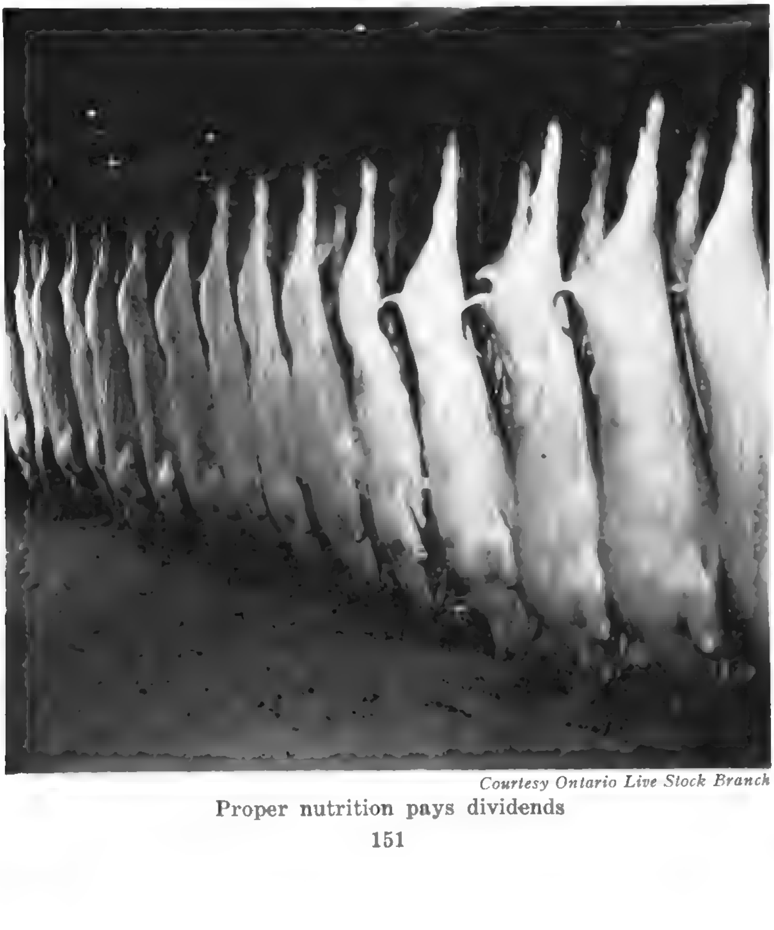
The figures presented are based on a herd comprising 8 sows, four mature and four young ones, and a boar. As might be assumed in such a breeding unit, the young sows farrowed at one year of age and the mature sows were bred for two litters in the year. Accordingly, the sows were bred for 12 litters in the year. Considering the mortality in the young pigs and the failure of the occasional sow to breed, an average of seven and one-half pigs weaned per litter or 90 pigs from 12 litters is about what might be expected. Some losses will occur after weaning, too, and in this study the loss was about average with 84 of the 90 pigs reaching a market weight of 200 pounds.

For the mature sows in this study, the average daily intake for the year was 7½ pounds of barley equivalent. The young sows farrowing at one year of age had a lower feed requirement; the total required to carry each young sow until her first litter was weaned was 1,920 pounds of barley equivalent. The boar's requirement for the year was at the rate of 7 pounds of barley equivalent daily, a total of 2,555.

Under dry lot conditions, with winter as well as summer feeding, close to 375 pounds of grain and 375 pounds of skim milk or buttermilk, will be required to make 100 pounds of gain in feeder pigs. These amounts of feed, according to methods of computation explained already, would have a barley equivalent of 450 pounds. Each pig weaned at a weight of 25 pounds and marketed



Quality Wiltshire sides at a Canadian Bacon Show.
Proper feeding is essential to good carcasses.



Courtesy Ontario Live Stock Branch

Proper nutrition pays dividends

at 200 pounds would require feed to make 175 pounds of increase in weight, an amount equal to 787.5 pounds of barley or its equivalent. The net energy values for barley and wheat are approximately the same, pound for pound, both having a Canadian Feed Unit Value of 1.0.

The total feed in terms of barley fed to the herd for the year, was:

1 boar	2,555 lb.
4 mature sows at 2,737 pounds	10,948 lb.
4 young sows at 1,920 pounds	7,680 lb.
84 market pigs at 787.5 pounds	66,150 lb.
Feed consumed by six pigs which died after weaning but before reaching market weight	1,632 lb.
Total feed used to produce 84 market pigs	88,965 lb.
Total feed used per 100 pounds of marketable pig	529 lb.

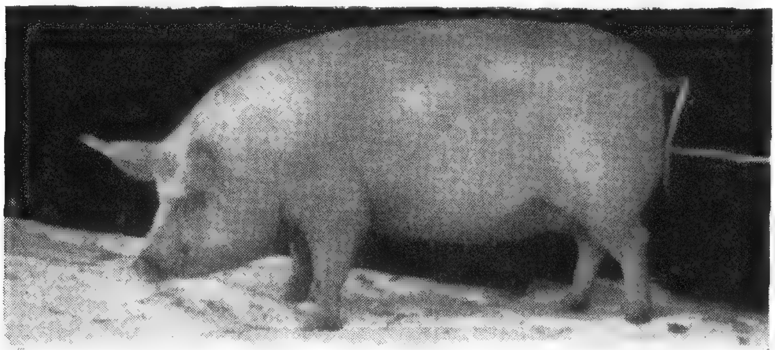
A shipment of well fed pigs

A review of certain cost of production studies in Canada and United States shows that feed accounts for about 78% of the total costs in pig production, the remaining 22% being made up by labour and overhead charges such as interest on investment, death loss and depreciation of breeding stock, cost of equipment and fences, and land charges.

Assuming that 529 pounds of barley are required to produce 100 pounds of gain in the live pig, 705 pounds would be required to produce 100 pounds of dressed carcass (basis 75%). If this represents 78% of the total cost of production and costs are to be expressed in terms of barley, it follows that the latter might be determined by multiplying 705 by 100 and dividing by 78; the answer is 904 pounds of wheat or barley to make 100 pounds of carcass. *Accordingly, if labour and overhead charges are to be accounted for, the farm price of 100 pounds of dressed carcass should exceed the farm price of 904 pounds of barley, before a profit can be shown.*

In the light of the foregoing, the return from wheat or barley fed as the basic grain to pigs and correctly supplemented, is about as follows:

Price Received Net for Pigs Marketed, Carcass Basis	*Feeder's Return Per Bushel of Barley*		*Feeder's Return Per Bushel of Wheat*	
	Basis of Feed Costs Only	*Labour and Over-head Included*	*Basis of Feed Costs Only*	*Labour and Over-head Included*
6 cents per pound.	.41	.32	.51	.40
7 cents per pound.	.47	.37	.60	.46
8 cents per pound.	.54	.42	.68	.53
9 cents per pound.	.61	.48	.77	.60
10 cents per pound.	.68	.53	.85	.66
11 cents per pound.	.75	.58	.94	.73
12 cents per pound.	.82	.64	1.02	.80
13 cents per pound.	.89	.69	1.11	.86
14 cents per pound.	.95	.74	1.19	.93
15 cents per pound.	1.02	.80	1.28	1.00
16 cents per pound.	1.09	.85	1.36	1.06
17 cents per pound.	1.16	.90	1.45	1.13
18 cents per pound.	1.23	.96	1.53	1.20
19 cents per pound.	1.30	1.01	1.62	1.26
20 cents per pound.	1.36	1.06	1.70	1.32



Yorkshire sow imported from England in 1944 by George Huffman

CHAPTER XVIII

THE NUTRITION OF DAIRY CATTLE

The dairy cow to present day society is a milk factory, and her udder has been pronounced the most important production unit in agriculture. Like other factories, this one needs raw materials. These raw materials are required, first to maintain temperature and keep the machinery in operation; secondly, for purposes of repair in the plant and finally, to enter into production. As in the automobile factory, the materials needed are of definite kind. Glass will not take the place of rubber and paint cannot be substituted for wood or metal in the automobile plant; so in the farmer's milk factory, the requirements are equally specific. Carbohydrates and fats may be interchangeable to a degree but other constituents are not, and because of the composition of milk, relatively large amounts of protein and mineral material are needed.

Perhaps the sheep and beef steer are the easiest animals in the barn-yard to ration because they are rarely expected to exceed more than a moderate rate of production. By the same token, the highly specialized dairy cow is the most difficult and most challenging, because she is expected to transform so much energy and devote so much of herself to production. A mature Holstein cow that produces the minimum amount of milk required in one year for qualification in Record of Performance in Canada, i.e., 12,000 pounds, actually yields in dry matter,

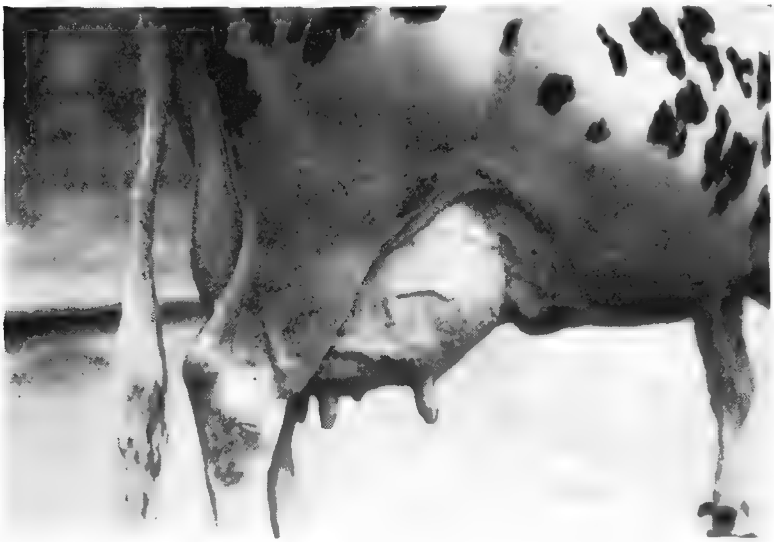
84	pounds of mineral ash
408	pounds of fat
576	pounds of carbohydrates
420	pounds of protein
1,488	pounds of dry matter

The total weight of dry matter in that amount of milk is three times as great as the dry matter in the body of a 1,200 pound cow. Such a cow, in the course of one year therefore, must produce three times the weight of her own body in milk solids. Thus the 1,200-pound milk producer yields roughly 1,500

pounds of dry matter in the form of high quality human food while the beef steer is doing well if he adds 300 or 400 pounds of dry matter to his body weight in one year.

Not only is the dairy cow outstanding in the extent of her productive operations but she is also an economical producer of human food. True, the vegetable products furnish cheaper human food, but of human foods of animal origin, dairy products are in a foremost position.

Quite obviously cows vary widely in performance; some are profitable and some not. It may be assumed that a cow's capacity *for milk production is fixed by heredity but that performance up*



Udder of Holstein cow, Colony Fleta Heilo, which in eight lactations produced 216,142 pounds of milk and 7,208 pounds of butterfat

to the limit of capacity is determined mainly by feeding. The majority of cows never reach the limit of their capacity and some others, to their own physical detriment, produce beyond the point where feed is adequate. Inadequacies in feed to milking cows result in decreased milk or in depletion of body tissues, or both.

But what is the relationship between high production and efficiency in production? And for the man who buys or supplies the feed, what level of production is most profitable? It might as well be made clear at the outset *that a "perfect" ration would*

not necessarily be profitable or practical, and that there is a point beyond which it would not be profitable to add cost to the ration. This demands more attention.

High production as it is achieved by good rations is desirable but so is efficiency in production. Efficiency is represented by the percentage of digestible feed material in the ration which is recovered in the milk: If an engine is 20% efficient, the power produced must be equivalent to 20% of the energy in the fuel. Drivers are told that the automobile is most efficient at a driving speed of 30 or 40 miles per hour; at that speed a car may be

A row of high producing Holstein-Friesian cows, property of Hays Ltd.

expected to travel 22 or 24 miles per gallon of gasoline; but at 75 miles per hour, the efficiency will be cut down to 14 or 15 miles per gallon. In measuring performance of dairy cows, there has been too much attention to "miles per hour" or pounds per year, instead of "miles per gallon" or milk return per unit of feed.

A herd performance would be much more significant if the number of Feed Units or the pounds of Total Digestible Nutrients required to produce 100 pounds of fat-corrected milk were stated. Among good cows, the average gross efficiency is about

30%. Poor cows will have a 15% to 25% efficiency and very good cows, 35% to 40%.

High production is usually, but not always, efficient production and there are times when something less than maximum production on modest rations is more profitable than maximum production on expensive rations. But the luxurious ration is an extremely rare cause of reduced efficiency in dairy cows; rather the main reason for a wide-spread inefficiency coupled with low average production in many parts of this country is improper feeding. The dual policy in Canadian dairying should be to weed out the poor cows and feed the good ones better. Thus production would be maintained on a higher plane of efficiency.

Feed Cost in Producing Milk. The relative costs in producing milk fluctuate a good deal from farm to farm and from one year to another. But it is generally agreed that feed costs account for half or more of the total costs. It is apparent then that the greatest hope for improved efficiency in dairy production lies in better feeding. The following is an approximate break-down of production costs:

Feed	52%
Labour	30%
Interest and depreciation on cows	7%
Building and Equipment costs	6%
Bull costs and miscellaneous	5%

Home-Grown Feeds. The main purpose of this chapter is to point to rations which will be practical and profitable as well as productive. With some thoughtful planning, home-grown feeds will meet nearly all the essentials of dairy rations, namely,

(a) Optimum bulk.
(b) Sufficient energy material.
(c) Correct levels of protein and essential minerals.
(d) Adequate provision of vitamins.
(e) Palatability.

The most common weaknesses in home-grown rations for dairy cattle have been, limited variety, low levels of protein and mineral matter in many of the common feeds, and finally, the necessity of resorting to mediocre or poor feeds in years of crop failure. In planning for wider use of home-grown feeds, two essentials should be a legume hay and plenty of good pasture.

Dry Matter and Energy. The total dry matter in the cow's ration should fall roughly between 2 and 3 pounds per 100 pounds of live weight. It is customary to compute the requirements of

roughage and of grain separately and it is not entirely wrong to suppose that good roughage alone will meet maintenance requirements adequately. It follows, therefore, that the grain or concentrate part of the ration is fed according to milk yield and to support milk production. This is a basis which is accepted by many feeders.

As a practical guide to rationing, where the roughage part of the ration consists of hay, it should be provided at the rate of 2 to 2½ pounds per 100 pounds of live weight. Thus a 1,000-pound cow would be given between 20 and 25 pounds of dry roughage.

If the roughage is to meet the needs of maintenance and the grain or concentrate part of the feed is to support milk production, it follows that the grain should bear some relationship to the quality as well as the quantity of milk produced. It must be clear that the nutritional cost of producing milk with 5% butterfat is greater than that of 3% milk. Two recommendations are made about grain allowance:

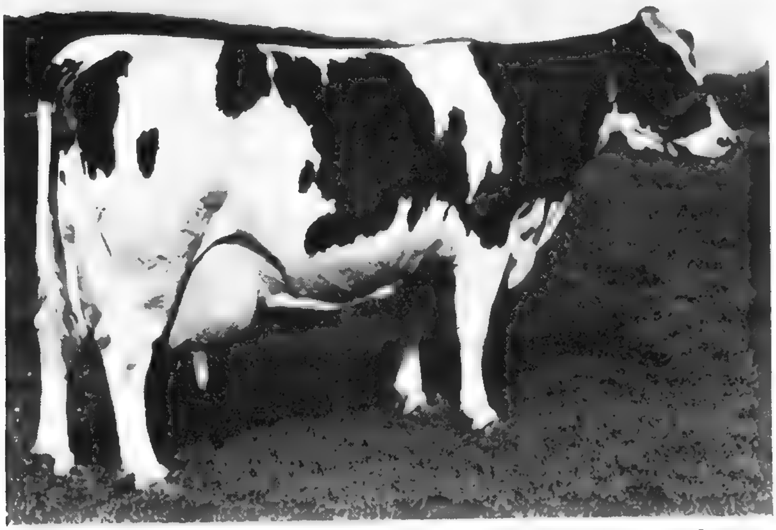
(1) One pound of grain per day for every pound of butterfat produced weekly. (By this rule, a cow producing 9 pounds of butterfat per week would be given 9 pounds of grain mixture per day).

(2) One pound of grain per day for every 3 or 4 pounds of milk produced daily. With milk testing below 4% fat, the grain allowance would be one pound per 4 pounds of milk. With milk testing 4% or over, the grain would be fed at one pound for every 3 pounds of milk produced daily.

There have been recommendations which have varied a good deal from these. *Boutflour*, an English authority, would feed more grain and less roughage. On the other hand, certain workers on this continent have urged more and better roughage as an aid to economical production. The view is gaining favour that with good alfalfa hay, the amount of grain can be reduced considerably, perhaps one pound of grain to 5 or 6 pounds of milk. This latter plan is certain to prove more practical and economical than the Boutflour system. In a Montana trial reported by Dickson and Kopland, (*Montana State College Bul., No. 293, 1934*), it was explained that cows fed one pound of grain to 3 pounds of milk produced, gave 30% more milk than cows fed no grain, but only 6% more milk than the cows getting one pound of grain to 6 pounds of milk produced. Such savings in grain, however, should not be considered except where supreme quality characterizes the roughage.

The Protein Requirement is High. If one were asked to name the major weakness in Canadian farm rations, the appropriate answer would be "insufficient protein". And no class of livestock is more affected by that deficiency than milking cows. A relatively high intake of protein must be maintained to provide for the output of a protein-rich product like milk. More than one-quarter of the total solids in milk is protein.

The protein requirement to meet maintenance in a 1,000-pound cow is set at 0.6 pound of digestible crude protein, and for production of milk testing 4% butterfat, the protein requirement according to the Canadian Feed Unit Standard, is 5.0 pounds of



Holstein-Friesian cow, Carnation Ormsby Madcap Fayne, whose production of 41,943 pounds of milk in 365 days became a world record

digestible crude protein for 100 pounds of milk. It is now supposed that after protein has been provided for maintenance, the digestible crude protein allowance to support production should be $1\frac{1}{4}$ times as great as the protein actually in the milk. The fresh cows and very high producers will justify the highest levels of protein, perhaps higher than the amounts just indicated.

Sudden changes in protein content of cow rations should be

avoided. A sudden and large increase can cause metabolic disturbance with a temporary increase in fat test.

The provision of the extra protein needed is an essential point in ration balancing. There are not many protein-rich feeds suitable for cows; they include legume hay, linseed oil meal, cottonseed meal, soybean oil meal, gluten feed, bran, meat meal and a few others. Of these, the only product which can be home grown in legume hay, alfalfa or one of the clovers, with a crude protein content of around 15% and a nutritive ratio of about 1:3.4. (The nutritive ratio of prairie hay is 1:10.7 and for oat sheaves 1:8). The only alternative to legume roughages for balancing is one or more of the mill feeds or commercial concentrates. The protein-rich feeds are always relatively expensive so the cost of a unit of protein rather than amount available becomes the main factor limiting use.

The Canadian grains carry from 12% to 13% of crude protein. With legume hay constituting one-half or more of the roughage part of the milking cow's ration, the concentrate part can be composed entirely of the common farm grains without any serious departure from the protein levels or nutritive ratios considered best. This means that a roughage ration of equal parts alfalfa and brome hay can be supported by a concentrate mixture composed of equal parts ground oats, barley and wheat, to give a nutritive ratio of close to 1:6, which is considered adequate for utility purposes. But to obtain the same protein ratio with grass hay alone as a roughage, would require the inclusion of about 15% of linseed oil meal or some other high protein concentrate.

To obtain a medium high level of protein where a non-legume roughage such as grass hay, oat sheaves or corn silage is used exclusively, calls for about 18% of crude protein or 14% to 15% of digestible crude protein in the grain ration. A great case can be made for the legumes in feeding milking cattle.

High, Medium and Low-Protein Feeds (Grains and concentrates)

High-Protein Feeds (20% protein & over)		*Medium-Protein Feeds (15% to 20% protein)*		*Low-Protein Feeds (Under 15% protein)*	
Linseed oil meal	(36%)	Wheat bran	(16.1%)	Barley grain	(12.1%)
Cottonseed meal	(39.4%)	Wheat Middlings	(17.4%)	Oats	(13.0%)
Soybean Oil meal	(40%)			Wheat	(14.0%)
Gluten feed	(25.9%)			Corn	(9.7%)
Brewers' Dried Grains	(21.8%)			Rye	(11.9%)
Malt sprouts	(26%)				
Meat meal	(55%)				
Fish meal	(60%)				

Mineral Supplements. With a heavy expenditure of mineral material in the milk, the cow is in danger of encountering serious deficiency of mineral elements. Unquestionably a serious depletion of calcium and phosphorus often occurs in mid-lactation and while it is not always apparent, there are various disorders including shy breeding, which can be ascribed to it. As a safeguard against depletion of these bone building elements it is necessary to provide calcium and phosphorus-rich feeds or supplements throughout lactation and the dry period at the conclusion of lactation. With high producing cows, some depletion during the period of maximum production will be inevitable even with good feeding.

Beef cattle subsisting almost entirely on roughages may encounter phosphorus deficiency, but rarely calcium deficiency. With dairy cows on a high intake of grain, the deficiency may embrace both calcium and phosphorus, but more likely the latter. Common supplements, such as bone meal and monocalcium phosphate, supply both calcium and phosphorus. If it is considered advisable to add to the calcium in these calcium-phosphorus supplements, ground limestone could be employed. Inasmuch as ground limestone carries no phosphorus, however, it would not be a suitable cow supplement by itself; in fact if used alone it might do harm by creating an unfavourable mineral balance.

The natural feeds rich in calcium are young grass and the legume hays; those rich in phosphorus are young grass, legumes, bran, and most grains and plant seeds.

There is no conclusive proof of wide-spread iodine deficiency in Canadian dairy herds. At least goitred calves occur but rarely and it has been concluded that pregnant ewes and sows are more likely to suffer from iodine deficiency. Nevertheless, producers should not overlook the possibility of reduced efficiency through "borderline deficiency" and in most parts of Canada, iodized salt is probably a wise provision. The commercially iodized product seems to be adequate for cattle.

The need for common salt in dairy rations is so generally understood that no further reference will be made to it here. Only in exceptional cases is there reason for supplying other mineral substances than those noted above.

Attention to Vitamins. The main objective in dairy herd rations is to ensure adequate quantities of vitamins A and D. A deficiency of vitamin D, the sunshine vitamin, may explain quite a few cases of rickets in dairy calves being raised by the skim milk method during winter months. The calcium and phosphorus needed to build strong, normal bones is present in the milk, but

if the vitamin factor is inadequate, the mineral material will be lost. The same vitamin factor is essential to the utilization of calcium and phosphorus by the cow, and must be provided in the feed if not through the action of sunshine.

Vitamin A deficiency occurs in dairy cattle of all ages. Carotene or vitamin A is necessary for normal growth, reproduction, health and production. And it must be provided through the feed if the milk and butterfat are going to carry a worth while amount. A deficiency in the diet of the dam may cause blindness in new-born calves and vitamin A deficiency may account for many of the breeding failures in dairy herds in middle and late winter when body reserves are low. There is no other source of vitamin A than the feed and the best carriers are green forage, green coloured hay, yellow corn and the supplement fish liver oil.

Feeders should be cautious about using much fish liver oil for milking cows on account of a tendency to depress fat test. But there are times when it should be used for calves and dry cows.

The Effect of Feed Upon Milk Quality. Fat content of milk fluctuates widely but otherwise the nutritional value remains comparatively constant and is affected only a little by feeds. Calcium and phosphorus percentage in milk is not changed by feeds and the same is true of protein. The exceptions are iodine and vitamins A and D. The iodine content of milk will be higher when cows get sufficient iodine in their rations, and in summer, the amounts of vitamins A and D in the milk are at least twice as high as when the cows are on plain winter feed. Accordingly about the only hope of "fortifying" cow's milk for human consumption through better feeding, lies with vitamins A and D, and iodine.

Carotene in plants is the natural source of vitamin A for herbivorous animals. It is abundant in green grass. Some breeds of cows transfer more carotene and less vitamin A to their milk than others and hence the richer colour in the milk of Guernseys and Jerseys. With Holsteins and Ayrshires, there is a higher percentage of this feed factor in the vitamin form.

Certain feeds like turnips, green rye, crested wheat grass pasture and French weed will impart an objectionable flavour to milk and cream and butter. The best method of overcoming this difficulty is to prevent the cows from feeding on such material for two or three hours before milking.

Avoid Uncertain Feed Mixtures. For the dairyman more than any other, the remedy for improper feeding is not a tonic or uncertain patent mixture but rather a study of the needs of the animal and a determination to fit a ration composed of basic feeds to the requirement.

Chapter XIX

THE PRACTICE OF FEEDING DAIRY CATTLE

The Dry Cow. In the case of heavy milkers, a dry period of 6 or 8 weeks prior to freshening is an absolute essential. It presents an opportunity to "build back" the body tissues and reserves, especially the minerals which enter into bone construction. It is inevitable that cows in heavy production suffer some degree of calcium and phosphorus exhaustion. Besides that, a cow freshening in good fit will milk longer and do it with a minimum expenditure of essential body tissues.

If the dry cow is thin, she should be fed to gain weight. Good pasture with water, salt and shade are the best conditioners possible. During the season of dry feeding, however, mixed hay and silage with from 2 to 6 pounds of grain, plus an allowance of calcium-phosphorus supplement will be needed. The latter is very important; bone meal or its equivalent would be an appropriate choice and might be mixed with loose salt or fed in the grain. Two per cent of bone meal in the grain is suggested. To what extent milk fever can be prevented or its incidence reduced by the fortifying of dry cows with the calcium and phosphorus present in bone meal, is not well established, but it is contended that there is a connection.

Calving Rations. For three or four days before calving, the grain part of the ration should consist mainly of bran. Bran is laxative and would help to prevent calving complications. The cow should be fed the usual amounts of clean roughage of good quality and given all the water she desires.

Immediately after calving, the cow will want water and it is extremely important that it be supplied with the chill removed throughout the first day or two. The same light, laxative rations are appropriate for a few days; heavy production of milk should not be encouraged until inflammation has left the udder and the danger of milk fever has passed. Indeed it should be mentioned here that the practice of leaving some milk in the udder at each milking for two or three days is a definite aid in preventing milk fever. It is a means of reducing milk secretion during that period and thus reducing the removal of lime from the blood until such time as the biggest danger of milk fever is passed.

During those first three or four days after calving, when major physiological adjustments are being made, bran is still a good choice for the major part of the concentrate feed. It can be fed dry, but preferably as a mash. To make a bran mash, one would place 2 to 4 pounds of bran in a bucket, thoroughly moisten it with boiling water, add a bit of salt and cover the bucket to let the mash soak and steam until it is cool enough to feed.

The newly-calved cow should be brought to grain ration gradually, taking two or three weeks to reach full production

Jersey cow, Volunteer Empress, Grand Champion at Royal Winter Fair, 1930

rations or longer if swelling and inflammation are slow to leave the udder.

At the well known Colony Farm in British Columbia, the standard feeds for the first weeks of lactation are hay and silage fed with a grain mixture consisting of 400 pounds of oats, 200 pounds of bran, 100 pounds of linseed oil meal, 14 pounds of salt and 14 pounds of mixed mineral supplement.

Feeding Cows in Milk. Milking cows should be fed as individuals. Consequently a small scale on which to weigh feeds is an important part of farm equipment. Cows are fed twice or three times a day, depending upon circumstances. It is a good rule to feed roughages twice daily and grains as often as the cows are milked. Those cows on R.O.P. test and being milked three times

a day would thus receive a mid-day feed. All grains for dairy cows should be ground or crushed but the fine grinding of roughages is of doubtful value.

As explained previously, it is fairly general practice to ration roughages on the basis of live weight, 2 to 2½ pounds of dry roughage such as hay, per 100 pounds of cow, and grains or concentrates according to production, one pound of concentrate mixture to every 3 or 4 pounds of milk production. With the very best quality alfalfa or clover hay, these allowances of grain could be reduced. The roughages used will therefore determine the type and quantity of grain to be fed. Roughages for rationing are usually limited to those in storage on the farm, while the concentrate part of the ration can be adjusted by the purchase of certain grains or mill feeds.

When silage is included, 3 pounds of silage would replace one pound of grass hay and if roots are fed, 5 pounds would take the place of one pound of hay.

The best grain mixtures for dairy cows should be neither very bulky nor very heavy. They should weigh about one pound per quart and contain not much over 10% of fibre. Such presupposes mixtures of two or more grains or grain products.

For a cow of average size (1,200 lb.) and making about 40 pounds of 3.6% milk daily, the ideal winter ration should meet the following practical specifications.

(a) Contain the equivalent of 25 pounds of air-dried roughage.

(b) Include a succulent feed, silage or roots.

(c) Include a legume hay, preferable up to 60% of roughage.

(d) Include between 8 and 10 pounds of grain or concentrate mixture.

(e) Possess variety, palatability and healthful qualities.

(f) Be adequate in point of energy, protein, mineral and vitamin materials.

Rations. In the ration examples which follow, the roughage is estimated in each case for a cow weighing approximately 1,200 pounds, and the grain mixtures are intended mainly to show proportions, but are here computed on the basis of an allowance of 10 pounds daily.

The first two rations are shown as examples of inadequacy for milk production, being too low in digestible nutrients and too low in protein; the low value for protein is indicated by the protein percentage and the nutritive ratio.

I. 24 pounds of oat sheaves

10 pounds barley

Nutritive ratio 1:8
Grain ration 12.1% crude protein
Total ration 10.2% crude protein

II. 12 pounds brome hay
12 pounds oat sheaves

5 pounds oats
5 pounds of barley

Nutritive ratio 1:7
Grain ration 12.5% crude protein
Total ration 9.0% crude protein.

The following ration suggestions are types which meet most requirements in practical dairying. Rations A and B contain a legume and a succulent roughage; C and D carry the legume but not the succulent feed; E and F have the succulence and no legume, and G and H have neither legume nor succulence. In each case however, a nutritive ratio of between 1:5.5 and 1:6.5 has been achieved.

Colony Flood Colantha, all-time, all-American three-year-old Holstein winner to 1944. Seven lactations averaged 19,858 pounds of milk and 651 pounds of butterfat. Bred and owned by Colony Farm, B.C.

A. 40 pounds swede turnips
8 pounds sweet clover hay
8 pounds oat hay

4 pounds barley
3 pounds corn
3 pounds bran

Nutritive ratio 1:6.2
Grain ration 12.6% crude protein

B. 35 pounds corn silage
12 pounds alfalfa hay

5 pounds oats
5 pounds barley

Nutritive ratio 1:5.8
Grain ration, 12.5% crude protein

C. 10 pounds alfalfa hay
12 pounds prairie hay

5 pounds oats
5 pounds barley

Nutritive ratio 1:5.8
Grain ration 12.5% crude protein
Total ration 12.0% crude protein

D. 24 pounds red clover hay

10 pounds oats

Nutritive ratio 1:5.4
Grain ration 13.0% crude protein
Total ration 12.2% crude protein

E. 45 pounds swede turnips
15 pounds oat hay

4 pounds oats
3 pounds corn
2 pounds bran
1 pound meat meal

Nutritive ratio 1:6.4
Grain ration 17.0% crude protein

F. 20 pounds sunflower silage
16 pounds prairie hay

5 pounds oats
3 pounds bran
2 pounds linseed oil meal

Nutritive ratio 1:6.4
Grain ration 18.5% crude protein

G. 24 pounds brome hay

3 pounds oats
3 pounds barley or wheat
2 pounds bran
1 pound linseed oil meal
1 pound soybean oil meal

Nutritive ratio 1:6.1
Grain ration 18.2% crude protein
Total ration 12.3% crude protein

H. 24 pounds oat sheaves

3 pounds barley or wheat
6 pounds oats
1 pound meat meal

Nutritive ratio 1:6.5
Grain ration 17.1% crude protein
Total ration 11.6% crude protein

Rationing for Big Records. Test cows being pressed for high records will be fed as close to capacity as is safe. Higher levels of protein, increased net energy and relatively restricted amounts of dry matter will characterize most test rations. The concentrates in such rations are always increased so that a higher percentage of the protein and energy intake will come from that part of the diet and a smaller percentage from roughage feeds.

Where the greatest possible effort is being spent to extend

Holstein-Friesian cow, Alcartra Gerben 420868, whose production of 1,409 pounds of butterfat in 365 days, completed in March 1945, constituted a world's record for all breeds. Owned by Hays Ltd.

individual production, the concentrate allowances are frequently up to 20 or 25 pounds daily; and some test cows have used well beyond those figures. *Canary Korndyke Alcartra* made a world's record as a four-year-old with 1,080 pounds of butterfat in 305 days, and did it on a comparatively modest ration, but she possessed unusual capacity for feed and took 30 pounds of grain feed daily for a long time. Her winter ration of roughage consisted of sweet clover hay and 30 to 40 pounds daily of sunflower silage. The grain part of the ration was

2 parts oat chop	1% salt
1 part bran	1% bone meal

The cow *Bella Pontiac*, bred in Ontario, established a Canadian record in 1921 with 1,270 pounds of butterfat and ate up to 33 pounds of grain feed per day. *Segis Pietertje Prospect* was on a concentrate level of 16 to 25 pounds daily for much of her record lactation in which she made history in 1920 with 37,381 pounds of milk in one year. Her grain ration was of the elaborate type, quite beyond the reach of the practical Canadian dairyman, but nevertheless of much interest. It was made up as follows:

6 parts oats
4 parts bran
3 parts corn
3 parts hominy
3 parts linseed oil cake
2 parts soybean meal
1 part cottonseed meal
1 part gluten feed
1 part ground flax
An allowance of molasses
1% charcoal

The Ontario cow *Jasmine Pabst Meg Posch* completed 31,791 pounds of milk and 1,167 pounds of butterfat in 1945, to make a world's record for three-times-a-day milking. Her ration was constructed along practical lines and included mixed hay, silage, beet pulp and a meal mixture carrying 15% of protein. Of the last she ate up to 18 pounds daily.

In January 1945, the world's record for both milk and butterfat production on twice-a-day milking passed to *Doncrest Peg Top Burke*, owned by Mrs. Edythe Brown of Stouffville, Ontario. The production for the 12 months was 31,935 pounds of milk and 1,108 pounds of butterfat. In this case the ration was good but not elaborate: the cow got no silage but was given mangels during the non-grass season. She pastured day and night between the first of June and early September and the concentrate part of her ration consisted of home-grown grains plus a 24% protein concentrate to make an 18% protein mixture. The dry roughage was mainly alfalfa hay.

The North American record for yearly butterfat production went in 1936 to *Carnation Ormsby Butter King*, with 1,402 pounds of fat from 38,606 pounds of milk. That cow ate about 20 pounds of mixed meal daily and in the grass season got 60 pounds per day of green forage. For the balance of the year, the ration apart from concentrates, was composed of:

15 pounds of corn silage	2 pounds molasses
12 pounds of beet pulp	20 to 40 pounds alfalfa hay
25 pounds of beets	

Alcartra Gerben. The Canadian Holstein-Friesian cow *Alcartra Gerben* who in March 1945 seized the world's record for yearly butterfat production with 1,409 pounds, received neither silage nor roots.

Her roughage consisted of brome hay, prairie hay, alfalfa hay, sweet clover hay and oat sheaves. The grain part of the ration had oats for its basis but with that grain were barley, brewers' grains, bran, fish meal, brewers' yeast, salt and a

Carnation Ormsby Butter King whose 365-day production of 38,606 pounds of milk at 1,402 pounds of butterfat constituted a dual world's record for a time. Property of Carnation Milk Farms, Seattle.

mineral mixture. Through most of the lactation, the grain mixture carried 18% crude protein but at the end of the period the protein percentage was stepped up and as much as three pounds of fish meal and two pounds of brewers' yeast were being fed.

Carnation Ormsby Madcap Fayne. The Holstein-Friesian cow *Carnation Ormsby Madcap Fayne*, a half-sister to Carnation Ormsby Butter King (both sired by *Matador Segis Ormsby*) holds the present world record for milk produced in one year with 41,943 pounds, (1,392 pounds of butterfat) a record completed at Carnation Milk Farm, Seattle, in 1942.

Like most record cows, she was big and so was her appetite. She was an unusually big eater of roughages. She completed her lactation weighing 1,750 pounds. But how was she fed? She was conditioned with good feed during the dry period and throughout the record lactation when her average daily milk yield was 115 pounds, her concentrate mixture was composed of wheat, corn, oats, soybean oil meal, linseed oil meal, corn germ meal and a mineral combination. The average ration was as follows:

18 pounds of concentrate mixture as noted above.
20 pounds corn silage
40 pounds sliced sugar beets and mangels.
10 pounds kale or fresh cut grass
35 pounds alfalfa hay of highest quality

The rationing of such record cows does not have a lot of practical application because the cows themselves possess more than average capacity for feed, and the rations are not of a kind within the reach of most dairymen. But at least these records show what can be done when a cow with potentially great capacity for production is well fed.

Roughages. The importance of the legume hays in dairy rations, test rations and utility rations alike, will now be obvious. As balancers, their only alternatives are high-priced cakes and mill feeds. The man with cows should spare no effort to grow a legume and recover hay of the best quality, green and leafy. Protein is highest in the early cut hay and in the leaves. The legumes may be used for pasture but there is a bloat hazard and actually their nutritional superiority as hay in the winter season is far greater than their superiority in the grazing season. Alfalfa is in first position as a hay for dairy cattle.

Of the grass hays, brome with its relatively soft texture and high percentage of leaf matter, is a favourite with cow feeders. Prairie hay, if it does not possess much "old bottom", is very satisfactory. Crested wheat grass and timothy hays can be used well but are not favourites. In most parts of Canada, well cured hay is not far short of silage in usefulness for milk production and may be significantly cheaper to produce.

Cereal crops if cut green, can be converted to useful hay but cereal straws are low in feeding value and should not be used to support any except very low levels of production. Oat and barley straw are better than wheat and rye straw, but even these have but little place in dairy rations.

Succulent Roughages. Silage, where its production is economical, is a useful but not an essential component of the ration.

Corn makes the most palatable silage and is used extensively in dairy communities. Sunflower silage is a suitable alternative in some northern districts where the season is too short for corn. Cereal crops make a satisfactory silage, but the legumes produce an ill-smelling silage unless a carbohydrate-rich product like molasses or green grass is added. The daily allowance of silage for a dairy cow varies from 10 to 40 pounds.

Roots, like turnips and mangels are enjoyed by the cattle and in Britain these are fed very extensively, often up to 60 and 75 pounds and sometimes over 100 pounds per day. In Canada, the most common daily allowance is 25 to 30 pounds. Whether or not roots should be grown for dairy cows is a question of cost of production; in many parts of this country the cost of producing a pound of dry matter in roots is comparatively high and they are not grown extensively except in eastern districts.

When turnips are used, they should be fed after milking rather than before, to prevent a tainting of the milk. Roots are usually pulped or sliced before feeding but cattle with good teeth can eat them in the unprocessed state.

Grains and Grain By-products. Ground oats form the basis of the grain rations for cows in most parts of Canada. This grain is palatable and safe to feed. Barley and wheat are rich in carbohydrates and more fattening than oats. Those two grains have about equal feeding value and can be fed as a portion of most grain rations to good advantage. One or the other of these will usually supply energy, or calories, or feed units more cheaply than other concentrates. Because they are heavy, however, they should be fed in conjunction with more bulky feeds. Corn is palatable; it is, roughly, in the same category as wheat and barley, and may be used where price warrants. Rye resembles wheat in composition, but is unpalatable.

Bran is a desirable feed for dairy cattle and may be fed generously when price warrants. It is a safe feed,—palatable, laxative and fairly high in protein. Linseed oilcake is an excellent protein concentrate, highly palatable and stimulating. Cottonseed oil meal and soybean oil meal are used as protein supplements in some sections of Canada and both are practical supplements. Meat meal and non-oily fish meal carry close to 60% protein and are most effective protein balancers; however, because of the cow's lack of natural taste for them, these meals must be introduced to rations very gradually. Where fed successfully at up to a pound per cow, per day, they are often economical sources of protein.

Molasses is classified as a concentrate. It is highly palatable and laxative, and is often used to improve the palatability of low

grade roughages. But molasses is low in protein and has no balancing value. Its cost on the basis of Canadian Feed Units makes it comparatively expensive.

Brewers' wet grains are quite suitable for dairy cows. Much of the carbohydrate material is removed from the original barley as a result of the brewing process and the residue, called "wet grains", is relatively high in protein. Brewers' dried grains carry about 21% protein compared with 12% in the original barley. A big trouble with brewers' wet grain is its poor keeping quality. Dairymen who can secure it at an attractive price may feed 20 or 25 pounds per day of the mash and thus replace about 6 or 7 pounds of ordinary grain feed.

Salt. Cows need about an ounce of salt a day. It is good farm practice to mix one pound of salt with 100 pounds of grain feed, and also allow the cows access to additional loose or block salt.

Calcium and Phosphorus. When it is thought that sufficient calcium and phosphorus is not being supplied adequately in regular feeds, it is recommmended that edible bone meal be supplied at the rate of 1½% by weight or monocalcium phosphate at 1% or less, in the grain. An alternative is to mix salt and bone meal, two to one, or salt and monocalcium phosphate, three to one, and place the mixture in a hopper from which the cows can eat at will.

Summer Feeding. Good pasture is the best and cheapest feed for cows. Used under favourable circumstances, good pasture is almost a complete feed. But when its supply is restricted or milk production is extremely high, some other feed may have to be supplied. A soiling crop such as green corn or alfalfa will supplement summer pasture well, and under some circumstances, an allowance of from 2 to 8 pounds of a simple grain mixture might be provided.

Feeding the Breeding Bull. Herd bulls of the dairy breeds are rarely permitted to run with the herd. They should, however, have the benefit of green forage in their corrals during summer months. Good hay and a little grain to keep the bull in a medium state of fatness are appropriate for the winter season. A lot of silage or roots tends to make a bull slow. Medium rations, bulky but nutritious, good variety, and plenty of exercise are conducive to good breeding efficiency.

Feeding Dairy Heifers. Following weaning at four or five months, heifers intended for breeding should be fed to ensure steady growth but economy must be an important consideration. For summer months, good pasture plus water and salt, are all

Ayrshire cows on a good mixed pasture

the feed that would be required; and for winter, the heifer will grow satisfactorily on roughage of top quality. The best winter rations for heifers will include legume hay ,grass hay and silage or roots. A pound or two of grain a day would be beneficial. In Western Canada, where the silage or roots are not as readily available, the mixed legume and grass hay with a little grain furnishes satisfactory growth and development.

Pregnancy throws some extra burden upon heifers and calls for a corresponding upward adjustment in feed, especially if the heifers are not in good condition. Jersey heifers are frequently bred to calve at 24 to 27 months of age, and Ayrshires and Holstein-Friesians at 30 months.

Water. Cows in milk need much water, up to 20 gallons a day. Where they do not have constant access to drinking water, they should be given all they will take at least twice daily. If the cows are watering outside in cold weather, the use of a tank or trough heater is advisable. They will drink more and enjoy it.

Conclusion. A knowledge of nutrition and feeding is something which the dairyman more than any other live-stock man, can use every day. He may discover that nutrition holds the answer to most of his problems in achieving maximum as well as economical production. It will bear repetition that "heredity determines a cow's capacity to make milk and feeding determines the extent to which performance approaches capacity. Growth, fertility, activity and resistance to disorder are also influenced by careful feeding practices."

CHAPTER XX

FEEDING DAIRY CALVES

Dairymen are constantly seeking good heifers for replacement purposes in the milking herd. There may be no justification for raising dairy bred males except such pure-breds intended for breeding purposes. With a replacement rate of somewhere between 20% and 25% in cow herds, the need for good heifers is perpetual, and the problem of raising them economically is ever important.

Milk is the most nearly perfect feed for young animals but dairy bred calves, for economic reasons, are destined to take their milk in an unnatural manner and often in reduced amounts. The practical problems attached to the feeding of dairy bred calves are quite different from those encountered in feeding other classes of farm stock. Beef calves for the most part are permitted to run with their mothers until weaning time and thus consume whole milk which is always fresh, sweet and at the correct temperature. Furthermore, they take their milk at frequent intervals during the day and thereby consume large amounts without overtaxing the digestive tract at any time. It is true there is an important difference in quality between the feed of a nursing calf and that of a pail-fed calf but it may be that method of consumption is just as vital a difference. The more nearly dairymen can bring feeding methods in line with natural feeding habits, the more success they will attain. Fortunately milk from which cream or butterfat has been removed is still a useful feed for dairy calves, particularly if properly supplemented or "fortified".

Colostrum

The calf is born with certain nutritional handicaps and unless they are overcome the young animal may fail to adjust itself to its surroundings. The colostrum or first milk of the dam is capable of meeting the natural requirements. Indeed it is of more vital importance than most dairymen realize to have the calves get that first milk and preferably within two or three hours after birth. Colostrum is ten times richer in vitamin A than ordinary milk and carries twice as much niacin. It carries about 15.5% protein with more globulin protein which helps to build

resistance to certain disorders, (normal milk contains 3.5% protein) ; it is about twice as rich in mineral matter as ordinary milk, and it is laxative and stimulating. The influence of the colostrum in increasing disease resistance is considerable, whether it is the result of the high vitamin A content, the protein value, or something else. All in all the calf which is denied its mother's first milk may suffer permanent handicaps. For that reason many dairymen now leave the new-born calf with its mother for one or two days after birth.

It may be a little more difficult to teach the calf to drink from

A Provincial Sweepstakes Competition for dairy calves, Saskatoon, 1944

the pail after it has spent 24 or 48 hours with its mother but a patient operator can overcome that slight disadvantage. Modern science has nothing better to offer in teaching a calf to drink from a pail than the old-fashioned method. By that method (1) the calf is backed into a corner; (2) the operator straddles the calf and places two fingers in its mouth; (3) the calf's head is lowered into a bucket containing some milk; (4) the operator perseveres until the calf discovers the art of drinking without drowning.

Irrespective of the method of feeding it is best to supply

whole milk for the first three weeks of the calf's life. The first feeds from the pail should be small, about one pound of milk for each ten pounds of live weight daily for the first few weeks of life; thus an 80 pound calf at birth would receive 8 pounds of milk a day. This amount should be broken up into at least three feeds, so that the stomach will not be distended unduly. Reference has been made to the fact that the stomach capacity of the average new-born calf is around five pounds of milk. To give the calf opportunity to take more than that amount would be to invite digestive trouble. Calves raised by pail will frequently develop depraved appetites and try to consume more milk than the stomach can reasonably accommodate. Frequent feeding of small amounts of milk is always best. More calves are likely to be injured by overfeeding of milk than by underfeeding. The milk, of course, should be sweet and clean and the temperature should approach blood heat.

Skim Milk Supplements

It is usually practical to ration dairy bred calves on skim milk after the age of three weeks. The gradual change from whole to skim milk should cover a period of ten days or two weeks, and when the change has been inaugurated a fat substitute or skim milk supplement in the form of a calf meal should be added to the milk and increased gradually in amount until the feed value resembles that of whole milk. There are many commercial meals that will give satisfaction but experimental work has indicated that certain home-made calf meals can be prepared successfully and at small cost. Ground flax from good sound seeds can be used as calf meal. There have been cases of poisoning arising from the feeding of raw flax, particularly if it has been frosted and of low grade; this is the result of prussic acid and can be overcome by boiling any questionable flax. Flax seed jelly is used extensively and can be prepared by simmering two pounds of flax in one gallon of water until a jelly forms. One tablespoonful of this jelly may be fed daily in the milk when the first skim milk is fed and the amount of jelly increased to roughly half a cupful daily at eight weeks of age.

A simple calf meal which gave good results in a five-year experiment at the University of Saskatchewan consists of equal parts by weight of ground flax seed, corn meal and wheat middlings. The meal was fed at about standard rate of intake for such feed products, namely one tablespoonful daily when the first skim milk was fed and up to one-half pound daily at the end of five weeks.

Skim Milk Powder

One part of skim milk powder by weight and eight or nine parts of warm water will furnish a possible substitute for ordinary skim milk for calves. The usual feeding precautions, of course, must be exercised, such as cleanliness, supplements, frequency of feeding, temperature, etc. The comparatively high price of skim milk made from the powder restricts its use in general feeding practice; if, for example, skim milk powder sells at eight cents a pound, the reconstituted skim milk will cost the feeder 80 cents per 100 pounds. Dairymen agree that such a cost for skim milk or its equivalent is not justified except in small amounts in calf gruel mixtures, or where particularly valuable calves are involved.

Rearing Calves on Minimum of Milk

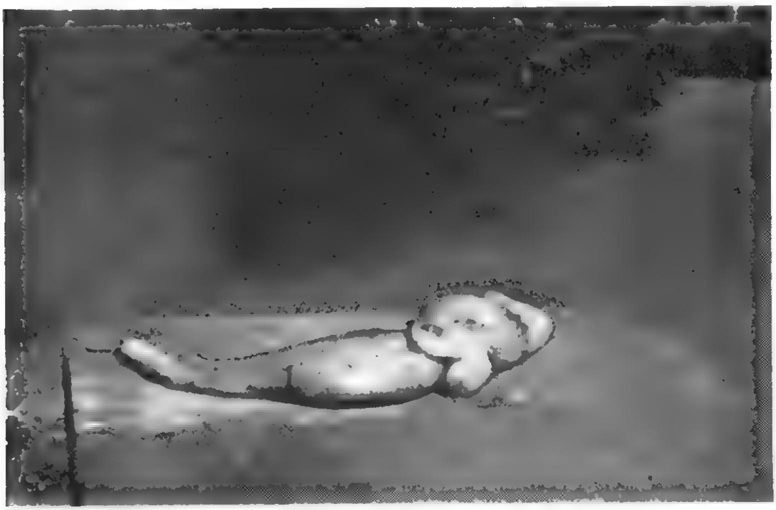
Where calves are to be reared on a minimum of milk the feeding problem is doubly difficult. Here again however, whole milk should be fed for the first three or four weeks. At the end of that period a gradual switch can be made from whole milk to a calf gruel made by adding water to a suitable meal. Such a gruel might be composed of one pound of the meal by weight and six or eight pounds of warm water. The same calf meal which is recommended for use with skim milk has been fed as a gruel, but better results will be obtained if about 25% of the meal is composed of skim milk powder or if 15% is blood meal, thus bringing the crude protein value to something over 20%. A feeding schedule provides for the first gruel to be fed with whole milk at the fourth week in the calf's life and also for the calf to be on gruel with no milk at the end of the eighth week.

Where a minimum of milk is fed to calves in early life there will be new nutritional challenges to the feeder. It must be remembered that the calf at birth has a non-functioning rumen, the stomach compartment in which the B-vitamins are synthesized; hence if a milk substitute is used, vitamin B supplements may be needed. For the first three or four weeks at least, a calf must be fed as if its stomach were of a simple type with a single compartment, and even for some time after the use of milk substitutes should include supplemental vitamin A and niacin. It is a sound practical policy to supply not only some reliable fish liver oil but also a little brewers' yeast daily when less than the normal amount of milk or skim milk is fed. As an alternative to brewers' yeast which contains most of the B vitamins, the feeder could use the crystalline form of niacin.

Dry Meal Method. This new method is meeting with increasing favour in dairy communities where it is necessary to raise calves

on a minimum of milk. In this case a high grade meal having a crude protein content of about 20% to 25% and adequately fortified with minerals and vitamins, is fed in place of the gruel. The dry meal is kept before the calf continuously from the age of 10 days. Good hay and water are likewise available at all times, and milk is given in the usual manner for one month and then it is gradually withdrawn.

Calf Scours. Calves which are strong and healthy take up to 20 pounds of milk a day from the age of two months. Over feeding of milk, however, is very harmful to the dairy calf and accounts for much of the indigestion and scours, and the resulting unthriftiness which are too common. Cold or sour milk or unsanitary quarters will affect the calf in a similar manner. When



The stomach from a new-born calf

scours occur, the allowance of milk should be reduced immediately and the calf given from one to two ounces of castor oil. A few tablespoonfuls of lime water in the milk may also prove effective in checking mild cases of the disorder.

It now appears certain that many cases of calf scours have a nutritional origin. One can tell from the surroundings whether the lack of sanitation is the main cause, and if not, the ailing calves will likely respond quickly to the feeding of some selected vitamin supplements embracing vitamins A and C and nicotinic acid or niacin. There is every reason to believe that improper

nutrition is frequently an important factor in the occurrence of calf scours.

The milk from cows on winter rations is commonly low in vitamin A. Furthermore, most of the vitamin A in cows' milk remains with the butterfat and consequently the skim milk given to calves may be very lacking in this feed factor. Calves threatened with scours might be given a half teaspoonful daily of fish liver oil of high vitamin A potency, along with one-half to one ounce of brewers' yeast, for a week or two. The yeast may be given in the milk. Commercial concentrates of vitamins A, B, C, and D are available in capsule form to be given one per day for two weeks. The Wisconsin Agricultural Experiment Station endorsed the Boyer and Phillips formula by which each capsule would contain 5,000 international units of vitamin A, 50 milligrams of niacin, 250 milligrams of ascorbic acid and 200 international units of vitamin D. In some progressive dairy herds every calf is given such capsules for the first two weeks of life. The old practice of giving raw eggs to calves with scours may have had considerable value because eggs are high in vitamin content.

Other Feeds For Pail Fed Calves. Calves will display appetite for hard feed when only a few weeks old. Cattlemen are well advised to encourage that appetite by placing a small handful of whole oats in the feed pail after the milk has been consumed, after the first two or three weeks. A little later a mixture of whole or coarsely crushed oats and bran will be effective. In the case of dairy calves being fitted for show, a mixture of linseed oil meal and crushed oats is appropriate. A good general purpose grain mixture for calves and one which has been used by several of the most successful breeders of dairy cattle, consists of 40 pounds of crushed barley, (or wheat), 40 pounds of crushed oats and 20 pounds of linseed oil meal.

Some good roughage like choice alfalfa hay or green cut oat sheaves or hay should be provided when the calf is about three weeks of age as the consumption of such roughage hastens the distention of the rumen. At about eight weeks of age some silage or pulped roots would be appropriate. Reasonable exercise and access to sunshine are conducive to health, and during summer months it will be beneficial to allow the calves the run of a grass paddock. Protection from flies and mid-day sun is an essential part of good management; if these cannot be provided, the calves should be inside during the day and on the grass at night.

Veal Calves

The best veal calves coming to market weigh between 130 and 200 pounds. It is contrary to law to market calves for veal before they are three weeks of age, but nevertheless, too many dairymen make the mistake of keeping surplus calves until they are heavier than necessary.

The best veal is from calves raised on a whole-milk diet. The whole-milk diet is of course comparatively costly and it follows that the calves should be fed for only a short period beyond the three weeks. In France where veal was long considered a great delicacy among meats, the growers very commonly restricted the calves entirely to milk; even exercise was forbidden and so was access to sunlight.

Under practical conditions as they apply in Canada, veal calves should be ready for market at from five to seven weeks; there is no profit in any except top quality veal and the best policy is to feed a predominance of whole milk throughout the short life of the veal calf. When skim milk is used, supplements should be added.

Feeding Schedules for Dairy Calves

Age of Calf	*Skim Milk Method*			*Minimum Milk Method*		*Other Feeds for Use by Either of Former Methods*	
	Whole Milk lb.	*Skim Milk lb.*	*Calf Meal lb.*	*Whole Milk lb.*	*Calf Meal Gruel lb.*	*Grain lb.*	*Hay lb.*
First Week	8	. .	. .	8	. .	. .	. .
Second Week	9	. .	. .	9	. .	.	.
Third Week	11	. .	.	11	. .		
Fourth Week	10	4	1/8	10	2	1/4	1/4
Fifth Week	5	10	1/8	8	4	1/4	1/4
Sixth Week	. .	15	1/4	6	6	1/4	1/4
Seventh Week	.	16	1/4	4	8	1/2	1/2
Eighth Week*	. .	18	3/8	2	10	3/4	1
Third Month	. .	20	1/2	.	12	1	2
Fourth Month	. .	20	1/2	. .	14	1	3
Fifth Month	. .	20	1/2	. .	16	2	4
Sixth Month	.	20	1/2	. .	18	3	5

*Some succulent roughage such as roots of silage from age of eight weeks.

CHAPTER XXI

THE NUTRITION OF BEEF CATTLE

Beef cattle live and produce under more nearly natural conditions than dairy cattle and therefore, the problems of rationing are comparatively simple. Disorders associated with malnutrition are distinctly less common than in dairy cattle and pigs. When deficiency does occur, such as with pica or bone chewing, the reason is likely to be the unusually low content of phosphorus in the feed, rather than excessive burden of production.

One thinks of the beef cow as a creature somewhat more placid, more lazy, more philosophical and less likely to come to an early grave than the specialized dairy matron. Nevertheless, that beef cow should be robust and a good feeder. It is her duty to make enough milk to feed her calf well and at the same time maintain her own body in such state of fatness that she will be of considerable salvage value for meat purposes at any time. Easy fattening tendencies and conformation consistent with maximum production of quality beef, are essential characteristics.

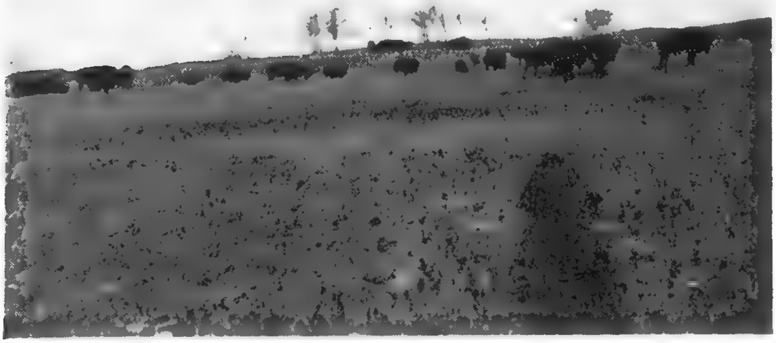
Grass, the Basic Feed. The main reason for the national importance of beef cattle is the fact that they are well adapted to the utilization of cheap feeds. As converters of grass to meats, they are supreme not only in Canada but in the world. He is a wise cattleman who gears his beef producing enterprise to the fullest possible use of grass.

In the Canadian ranchlands of South Western Saskatchewan, Southern Alberta and the Interior of British Columbia, the beef cattle enterprise depends almost entirely upon native grass. In some sections there is a little cultivation and irrigation, resulting in the production of alfalfa or oats or some other domestic crop for winter feed; but in much of those areas cattle population is related to the capacity of the native forage to supply feed for winter and summer.

Carrying capacity is expressed in acres required to maintain one cow or cattle unit for twelve months. In the Alberta Foothills, 30 or 35 acres should be sufficient to support a cow for a year while on the Short Grass Plains, around Medicine Hat for example, it may require 60 acres. This may seem like an extravagant use of land, but it should be remembered that much of the

ranch country is quite unsuitable for the production of anything except pasture. The grass, though admittedly not abundant, is of excellent quality. It is particularly good for beef cattle and produces a firm and high quality beef. Furthermore, these native grasses make excellent hay for winter feeding and if not cut for hay, they will cure, uncut, and afford good winter grazing when weather conditions are favourable.

In contrast to the low carrying capacity of ranchland grass is the productivity of domestic grasses in many parts of the farming areas. In parts of Eastern Canada where the soil is fertile and mosture conditions are favourable, pastures will support up to one head per acre for the summer grazing season.



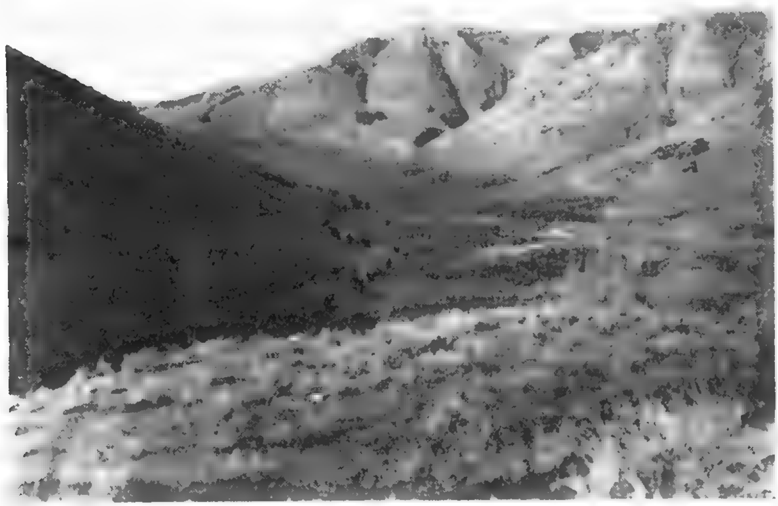
Buffalo at Wainwright

Maintenance of Beef Cattle. The Feeding Standard states that for every 1,000 pounds of live weight, the beef cow should get from 18 to 23 pounds of dry matter daily to keep the digestive organs at an optimum state of fullness, and the feed should provide 8.2 Canadian Feed Units containing at least 0.6 pound of digestible crude protein to maintain her body without production and without loss or gain in weight. What does that mean? It means that a daily allowance of two pounds of brome hay (90% dry matter) for 100 pounds of live weight would meet the requirements for bulk and provide all the energy and protein needed for maintenance, with a little to spare. This is quite in

line with the opinion of practical cattlemen that beef cows wintering on good hay and fed 22 to 28 pounds daily, will more than "hold their own" in condition. Even the poorer roughages such as oat straw can be worked into winter rations for cows on maintenance because in the physiological work of digesting those fibrous feeds, a good deal of heat is generated and this helps to maintain body temperatures.

But when beef cows produce 25 or 30 pounds of milk daily to feed a calf, there is an immediate need for more feed. Good grass would meet the requirement but if it should be in the non-grass season, a "hay plus grain" ration becomes necessary.

The Way Fattening Cattle Use their Feed. The feeding of fattening cattle is quite different from the feeding of the breeding herd; it is definitely a matter of "maintenance plus". Fattening cattle are working cattle, but unlike milking cows, their form of



Cattle coming out of river breaks, Matador Ranch, Saskatchewan

work or production does not require high levels of protein. Carbohydrates in the feed constitute the most economical source of animal fat and carbohydrate-rich rations are most economical and most commonly used for fattening.

Margin. A pound of fat contains more calories than a pound of carbohydrates or protein and a pound of fat on a steer represents a greater expenditure of feed than a pound of growth. The

Feeder calves weighing 420 pounds, raised by Wm. Sidey of Alberta

Courtesy Ontario Live Stock Branch

Group of Calf Club boys from Simcoe County, Ontario. Union Stock Yards Show, 1944.

cheapest gains in beef cattle are not made in the fattening pen. In many cases it will cost as much or more to produce a pound of gain in fattening cattle as that pound of live weight is worth on the market. Where that is the case, the cattleman must look to the increased value of the original weight to furnish the profit. The difference between the market price of the feeder steer delivered at the feed lot and the price of the finished steer at the market, is called margin and in fattening cattle, a margin of at least two cents a pound should be sought. It means that where average feed conditions obtain, a feeder steer bought at 8 cents a pound should sell at 10 cents a pound when finished, in order to ensure a reasonable margin.

Gains. Thin cattle when healthy, make the most rapid and economical gains but require a longer feeding period. In the ordinary course of events, the cheapest gains are obtained early in the fattening period. The fatter a steer or heifer becomes, the more costly in feed becomes the gain. Thus holding market cattle after they have reached the most desirable finish, is extravagant and unprofitable.

It is true that young cattle will make a unit of gain in weight with less feed than older cattle. But why? Is it that the digestive system of a young animal is more efficient than that of the older one? The answer will be clear when it is understood that the body of a young animal contains a higher percentage of water than that of an older or mature animal. Of a pound of weight added to a fattening yearling, more of it will be water than would be the case with a three-year-old. There are certain well understood advantages for yearling and two-year-old feeders, faster gains, lower mortality, use of plainer feeds, etc., but for the younger cattle there is a clear cut case of economy.

Feed Supplements. It must be clear that beef cattle production can be supported in most cases by home-grown feeds and salt. One of the exceptions is the need for supplemental phosphorus where a deficiency is noted when they are on plain winter feeds without grain or on pastures in dry years. In the summer season at least, they need bone meal or mono-calcium phosphate or some other phosphorus-rich supplement. A little legume hay with its high content of protein and bone-building minerals will pretty well ensure against such deficiencies during the winter season.

Iodine deficiency in beef cattle in Canada is not common. Goitered calves, however, have occurred from time to time and iodized salt is a wise supplement. Certainly salt is needed at all times and lake salt or slough salt will not take the place of common salt (sodium chloride).

The Vitamins. When it is a case of vitamin requirements, the position of the beef cow is comparatively simple. Nature has provided for the manufacture of the "vitamin B family" through the action of bacteria in the paunch; vitamin C is not believed to be needed although there have been reports of non-breeding bulls responding favourably to injections of ascorbic acid.

Cattle on summer grass will secure all they require of vitamins A and D. With good body reserves of these factors carried into the winter, the common feeds will usually supply non-lactating cattle with enough to prevent manifestations of deficiency. Here

Grand Champion Hereford bull at Calgary Bull Sale, 1945, Perfection Domino L.R.D. 100 -155458-. Shown by W. J. Edgar, Innisfail.

again there are exceptions; fall-born calves will suffer from deficiency of vitamins A and D during winter months unless feeding conditions are favourable, and fattening baby beef on plain feeds have sometimes developed defective vision and night blindness. This latter is an indication of vitamin A deficiency, a deficiency which could be prevented by the use of good quality alfalfa hay or fish liver oil.

With beef carcass standards as they are, however, the feeder

of fattening cattle may be obliged to avoid large amounts of certain feeds rich in carotene, the parent of vitamin A because it imparts a yellow pigment to the beef fat. Yellow corn and alfalfa hay with rich colour are good sources of carotene and when fed fairly heavily will impart this yellow pigmentation. Green grass will do the same which is one reason for grass fed beef underselling grain fed beef. The carotene in the fat should enhance the nutritional value of the meat but it is not appreciated by the consumer and yellow carcasses are discounted in price. This drawback can be overcome however if the feeder discontinues those feeds which contribute to the fat pigment a few weeks before marketing his cattle.

West Highland cattle "at home".

CHAPTER XXII

THE PRACTICE OF FEEDING BEEF CATTLE

Complicated rations are not necessary for beef cattle. Most breeding herds run on range or pasture during summer months and live on rations which are almost, if not entirely roughage through winter months when maintenance is the chief consideration. Thus, summer feeding when the cows are nursing their calves, is a comparatively simple matter, and in the winter when the breeding herd is not working heavily, economical rations from home-grown feeds, are satisfactory.

Winter Rations for Breeding Cows. A good many cow herds of beef breeds are wintered on simple rations consisting of hay, salt and water. Where the hay is of good quality and the cows are not milking, such rations will cover maintenance. The daily consumption of hay will run from two to two and one-half pounds per 100 pounds live weight. The ideal hay for wintering beef cattle is a mixture of brome and alfalfa, and these hays would be very acceptable in almost any proportion. Prairie hay, blue grass hay, clover, western rye grass hay and oat sheaves are all good if cut at the right stage and well cured. In actual practice, the stage at which roughage feed is cut and the method of curing are more important in live-stock feeding than the forage species or variety. Early cutting means higher protein in the hay.

When it is necessary or expedient to feed cereal straw, it is well to keep in mind that,

(a) Cereal straws are low in net value and alone will not support maintenance.

(b) That cattle depending upon cereal straws for roughage should be given some two to six pounds of grain feed per day.

(c) That oat straw and barley straw are the best of the cereal straws.

Silage and roots replace a portion of dry roughage to good advantage where cost of production makes their use practicable.

The Grazing Season. The ideal pasture is one in which productivity fits the needs of the cattle so that there is plenty of grazing

and also continuous young grass over a long season. Overgrazing is obviously the most serious criticism of Canadian pastures but undergrazing will result in the grasses maturing more quickly with a certain loss of nutritional quality. Legumes do not possess the same degree of superiority among pastures as they do among hay feeds, and there is a danger of bloating when cattle are pastured on fields in which alfalfa or other luscious legumes predominate. Nevertheless, the best domestic pastures will contain a mixture of species, with at least a little alfalfa or clover.

Good pasture management provides for plenty of water, salt and shelter or protection from flies.

Plenty of Water Will Reduce Digestive Troubles. Insufficient water during winter months when cattle are on dry feeds is believed to be a common cause of impaction and indigestion. Where cattle drink at outside troughs in the winter season, they often become so chilled that they will consume considerably less of the icy water than needed for digestion and health. The logical alternative where such conditions exist is to place a heater in the trough to remove the chill from the drinking water. It is pointless to make the water actually warm, but the removal of the chill will result in a definite increase in water comsumption in cold weather and go a long way toward preventing impaction. Cattle should get water at least twice daily in winter and summer and cattle on range should have water within 2 or 2½ miles of all grazing.

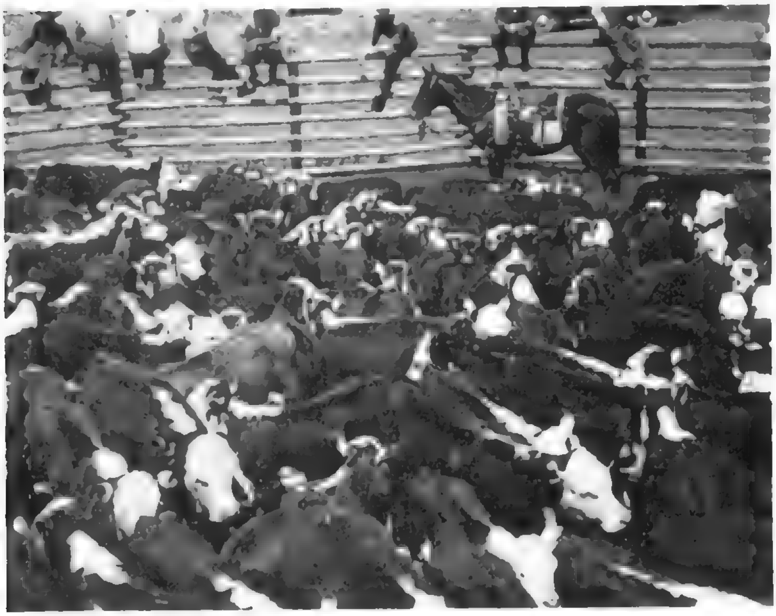
Beef Calves. A common range of weights for calves of beef breeds at birth is 60 to 90 pounds. All calves on Canadian ranches and most beef calves in farm herds are born in the spring season and are allowed to run with their dams through the summer. The calf born on grass enjoys natural advantages. When the milk supply is reasonably good, calves weaned at 5 or 6 months should weigh between 350 and 400 pounds.

Calves running on good pasture with their dams need but little extra care. There are, of course, such matters as castration of males and vaccination where the latter is considered advisable. Attention must also be given to creep feeding. Tests show that more weight at weaning time and better calves for fattening later, are the rewards of providing a little special grain feed after the sucking calves are three months old. This feed, consisting simply of whole oats or whole oats and bran, can be placed in a box or trough to which the calves, but not the older cattle, have access. The mechanical arrangements are not difficult consisting simply of a small pen with an opening through which only the calves can enter.

Those calves of dual purpose or beef type which are raised by hand or "pail fed", should be handled according to the instructions given for dairy calves.

The points of practical importance in rearing calves by hand are:—

(1) Colostrum for the new-born.
(2) Correct amounts of milk, with no overfeeding.
(3) Whole milk for two or three weeks and then skim milk and supplementary feeds.
(4) Sanitation care.



Calves at a July round-up, waiting their turn to be branded.

Feeding Bulls of Beef Breeds. For young and growing bulls which should be neither very fat nor yet very thin, some legume hay is a most valuable part of the ration. It can be fed in conjunction with some grass hay or oat sheaves. A moderate allowance of ensilage or some roots is fine for the young bull but much of either of these products tends to make the breeding bull slow.

The grain for young bulls should be basically oats, but if more fat is required, barley or wheat can be added to the extent of 50% or 60%. With those who fit bulls for show or sale and desire a fairly high state of fatness, boiled barley will prove effective

and linseed oil meal in small amounts will impart the characteristics of quality to hide, hair and flesh. Up to a pound a day of the linseed oil meal can be recommended.

Most beef bulls run with the herd during the breeding season in summer months but for those bulls which are "hand-bred", a grass paddock affords the best summer time feed. Winter rations for mature breeding bulls consist of about two pounds of dry roughage or its equivalent per 100 pounds live weight and from two to eight pounds of mixed grain depending upon the bull's condition. Lack of exercise and overfatness are two chief causes of shy breeding. Bulls which show a tendency to deposit a lot of fat in the upper part of the scrotum, should be fed most moderately if good breeding efficiency is to be ensured. On plainer rations some bone meal or other calcium-phosphorus carrier should be provided.

Mineral Supplements. Cattle require salt regularly. For fattening cattle or others receiving a heavy ration of grain, the salt can be added to the grain mixture at the rate of 1% by weight. For all other cattle, it should be provided as loose or block salt, where the animals will have access to it daily. Iodized salt represents a reasonable choice, even though iodine deficiency is not much in evidence.

Breeding beef cattle which consume large amounts of roughage and not much of plant seeds, are likely to require supplemental phosphorus rather than calcium. In various parts of Canada there have been cases of bone-chewing and depraved appetites which point to phosphorus deficiency. In such instances,

Aberdeen Angus bulls at a Canadian bull sale

a supplement of ground limestone is wrong; rather, a supply of bone meal or bone char or mono-calcium phosphate should be placed where the cattle may have access to it. There is merit in mixing equal parts of bone meal and salt, or three parts of salt and one part of mono-calcium phosphate and placing the mixture in hoppers in the pasture or paddock. Perhaps breeding troubles and unthriftiness are more closely allied with phosphorus deficiency than most cattlemen have realized.

Fattening cattle on full rations of grain and good roughage will probably require no other mineral supplement than common salt.

Grain Fattening. The grain fattening or finishing of beef cattle to be marketed should be considered an essential feature of the industry. It is important as a means of,

(a) increasing total revenue from cattle.
(b) maintaining a better degree of soil fertility.
(c) raising the general quality of Canadian beef.
(d) affording an extra outlet for more Canadian-grown grains.

The profit from fattening commercial cattle has fluctuated a good deal from year to year but has been generally satisfactory. From winter feeding trials carried on for 12 years between 1921 and 1933 at the University of Alberta, it was shown that $1.00 worth of grain fed to the fattening steers, brought an average return over that period of $1.87.

The business of fattening is conducted by two groups mainly, (a) farmers who finish the cattle of their own raising on home-grown feeds; and (b) feed-lot operators who buy their feeder cattle and buy their feed. Both groups are important to the beef industry.

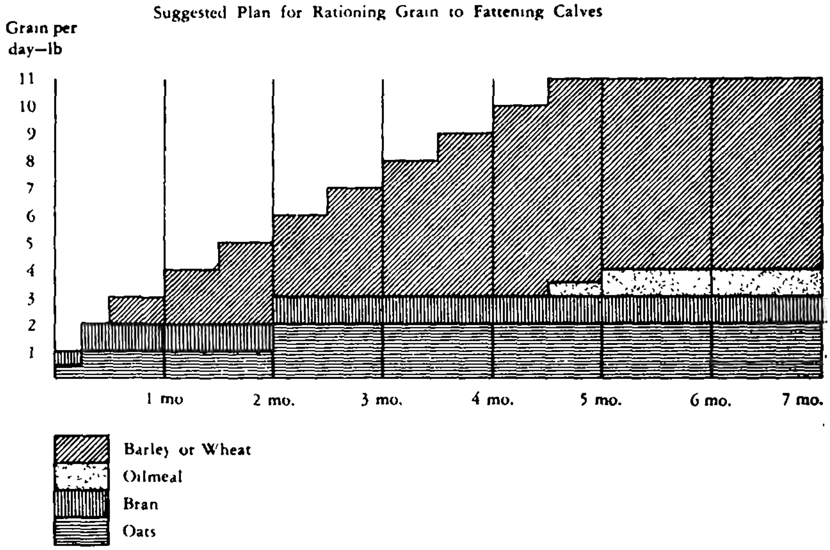
Starting Cattle in the Feed-Lot. The best results in fattening will be obtained where the feeder cattle are polled or dehorned, and where the animals are confined fairly closely. Stall feeding is practised where only a few head are involved, but for larger groups, pen or corral feeding is best. Corral feeding in groups of 20 or 30 head is quite practicable. In a 128-day feeding trial at Saskatoon in 1936 a pen of calves fed in an outside corral gained an average of 212 pounds while a corresponding lot fed in box stalls in the barn gained 213.5 pounds. Fattening cattle allowed to roam over a field use too much of their feed on body activity and thus make slower and less economical gains.

It is one of the first rules in live-stock husbandry that all feed changes be made gradually. Cattle selected for grain fattening should be brought to full feed slowly and cautiously. This is of

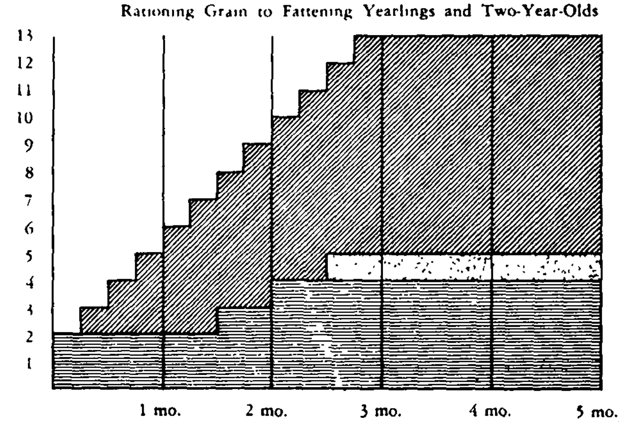
special importance in cattle which have never had grain feed previously. Good hay can be fed freely from the beginning and in such amounts as the cattle will eat with relish. Feeding twice daily is the common practice and is generally adequate.

The grain most favoured for starting feeder cattle is whole oats. Feeder calves starting at 400 pounds live weight might be given a pound of oats a day at the beginning, and yearling and older feeders could be started on two pounds. The objective is to bring the feeders to "full feed" as quickly as is safe. A per-

Suggested Plan for Rationing Grain to Fattening Calves



Rationing Grain to Fattening Yearlings and Two-Year-Olds



centage of heavier grain, barley or wheat or corn, coarsely ground, should be included in the course of a few days, and the proportion of the more fattening grain increased as the amount of total grain feed is increased.

Full Feed. The daily consumption of roughage will not change greatly as the fattening period advances, but the daily intake of grain feed should advance steadily. The per day allowance can be increased between half a pound and a pound each week for calves and from a pound to a pound and a half for yearlings, until full feed has been reached. Ten pounds of grain a day is regarded as a practical maximum for fattening calves and from 12 to 16 pounds per day for the older feeders. Where cattle are being fattened for show and special attention is being given to individual appetites, the figures for full feed would be exceeded.

The Self Feeder. The advantages and disadvantages of the self feeder in fattening cattle are as follows:

Advantages	*Disadvantages*
(1) Saves labour	(1) Increases risk of loss
(2) Produces fast gains	(2) Increases feed cost per unit gain.
(3) Results in more finish	

Calves must be started on self feeders very cautiously and gradually or death losses will occur. They should be brought up to full grain feed by hand feeding before being released at the self feeder. The increased grain consumption per pound of gain has amounted to 15% as compared with expert hand feeding. A fairly bulky grain feed or a mixture containing at least 30% or 40% of ground oats will be safest to feed from a self feeder.

Grains for Fattening. As a grain for starting the feeders, oats are unquestionably best, but barley or wheat should constitute 50% or more of the total grain mixture after the first month of feeding. Barley and wheat are both excellent for fattening and will impart a clear, white, firm fat to the carcass. Boiled barley is highly regarded by feeders of show steers and also by some commercial feeders. It has special value in hastening the fattening process. Rye is also fattening but is unpalatable and unpopular unless mixed with other grains. Bran on account of its laxative and bulky nature, is a safe concentrate and is good in small amounts, especially with barley if the oat grain is not prominent.

An allowance of linseed oil meal, up to a pound a day in the regular grain mixture during the last month or two of the feeding period, will whet the appetite and is an aid in developing a pliable hide, mellow fleshing and soft hair.

In the case of oats, barley and wheat, which are almost the standard grains for fattening cattle, medium grinding is best.

Roughages in Fattening Rations. Grass hay is most satisfactory as the basis of the roughage ration for fattening cattle, although some legume hay will help, especially when fattening calves. These young cattle are growing as well as fattening and require the extra protein material present in the alfalfa or sweet clover hay. Twenty-five to 50% of legume hay along with grass hay is excellent for fattening calves. Prairie hay and brome are two of the best grass hays for cattle. Silage and roots are very satisfactory as replacements for a small part of the roughage ration but are not essentials and not widely used for fattening cattle in Canada.

Supplements For Fattening. Fattening cattle need salt, but if the ration is constituted of quality feeds, it is doubtful if any other supplements are needed. The need for phosphorus and calcium supplements has not been confirmed. Saskatchewan

A Junior Beef Club Show

trials failed to show they were needed. Cattle being fattened on beet pulp will have a special need for supplemental phosphorus. Fattening calves may require something rich in vitamins A and D, if the feeds otherwise are low in quality. Some commercial feeders have supplied dirt sods to fattening cattle. A trial, supervised by the author, demonstrated that fattening cattle had an appetite for some earth, but gains were no better from the consumption of it.

Length of Feeding Period. Fattening calves usually require 200 or 220 days of feeding before reaching optimum market finish. Heifers do not gain as rapidly as steer calves but will reach a state of desirable finish earlier. Yearling cattle require 4 or 5 months of fattening in most cases, and two-year-olds will usually

fatten in less than 90 days. (Cattle fattening in less than 90 days of grain feeding are termed "short-keeps" and those requiring greater period of feeding are "long-keeps".)

With good rations, feeder calves should show an average daily gain of 1¾ or 2 pounds for the customary feeding period, while long yearlings and older cattle should make 2 to 2½ pounds daily. Show steers which are fed individually with special care often take 25% or 40% more meal feed than the amounts specified for commercial cattle and under most favourable conditions may show a daily gain in weight of three pounds.

Feed Requirements in Fattening. Fattening calves gaining from a weight of 400 pounds to 800 pounds can be expected to consume a total of 1,600 to 1,800 pounds of grain and 2,200 to 2,500 pounds of hay or other dry roughage. Older feeders which come to full grain feed more quickly than calves, will eat a higher percentage of grain in relation to roughage.

In feeding trials at the University of Saskatchewan between 1928 and 1943, the feed consumption per unit gain in calves and yearling feeders was as follows:

	Calves	*Yearling Feeders*
Dry roughage per 100 lb. gain in weight	603 lb.	508 lb.
Grain feed per 100 lb. gain in weight	445 lb.	604 lb.
	1,048 lb.	1,112 lb.

The above figures for calves are based on a total of 607 animals fattened during the period and it is significant that the average period of feeding for these was 220 days and the mortality was 1.5%

Feeding Cattle In Transit. To minimize shrinkage and deliver cattle in good condition at the market, heavy feeds and those which might contribute to scouring should be reduced a day or two before cattle are shipped. Ensilage and roots should be eliminated and grain rations cut to 25% or perhaps 10%. Hay is the most dependable feed for the period of transit. "Filling" cattle with feed or salting them to secure a heavy fill of water prior to sending them to market is a great mistake and often results in scouring and heavy shrinkage.

Cattle which have had good alfalfa hay or other feed rich in vitamin A during the period prior to shipping, may be in a better position to withstand the dangers of "shipping fever".

CHAPTER XXIII

SHEEP NUTRITION

Sheep are kept on a small percentage of Canadian farms. The total sheep population of 3,727,000 according to 1944 estimates, makes strange contrast with a 100,000,000 or more in Australia and 30,000,000 in New Zealand. Nevertheless, the sheep industry in Canada should not be considered as unimportant; there is good reason to suppose that lamb and wool production will expand. Sheep with their peculiar appetite for variety, their aptitude for eating weeds and their ability to utilize rough grazing and unsalable feeds, fit well into a mixed farming programme. Clearly no farm animal is so well clothed and able to withstand the rigours of northern winters. In addition Canadian flocks have produced only a fraction of the wool needed in industry, and the per capita consumption of mutton and lamb has been a mere 6 or 7 pounds per year.

Sheep are ruminants, and therefore have the same nutritional requirements as cattle. The natural diet is vegetation and they are well able to digest fibrous feeds. In point of fibre digestion, the human is a complete failure; the pig is only a little better, but the sheep and cow can break down and use about 50% of the fibre in their rations.

Like other vegetarian feeders, the sheep depends mainly upon carbohydrates in its ration to supply heat and energy; it must have food protein from which to manufacture body protein and thus build and repair muscle tissue. Mineral material or ash is needed to construct and maintain bones as well as for various other purposes, and the vitamins have their specific parts to play.

Admittedly, sheep are not as subject to nutritional deficiency as the hard working dairy cow or the quick growing pig. Lambs are born at a favourable season of the year and have the protective support of the dam's milk until they have achieved nearly half of their mature weights. Wintering ewes are carried on little more than a maintenance basis and milking ewes are usually out on grass. Consequently, the artificialities of domestication have created fewer complications for sheep than for most classes of live-stock.

Nevertheless, deficiencies do occur and poor nutrition may

seriously interfere with flock efficiency. The flushing of ewes as a means of securing a higher percentage of twin lambs has served as a fine demonstration of how better feeding can improve performance. Ewes heavy in lamb, ewes which are milking heavily and lambs in their first winter are the ones most likely to suffer from inadequate rations.

Insufficient protein in rations may account for more poor breeding records, poor milking performance and weak lambs than is generally recognized. Certainly a supply of good legume hay for winter use is of prime importance to the flock owner.

An experimental breeding flock at the Range Experiment Station, Manyberries, Alberta

Mineral Limitations. So far as mineral elements are concerned, common salt, calcium, phosphorus, iodine, and perhaps cobalt and copper, are the minerals most likely to concern the sheep man. Insufficient salt results in unthriftiness and about one-half ounce per day is needed by ewes and one quarter ounce by lambs. Sheep are subject to rickets, osteomalacia and bone chewing, all of which are caused by calcium and phosphorus deficiencies. Sheep which receive large allowances of grains may need supplemental calcium, but with sheep which depend largely or entirely on roughage feed, the greatest need is for extra phosphorus. Depraved appetites with the chewing of bones or portions of dried carcasses, is an indication of phosphorus deficiency which is very liable to reflect itself in breeding failures. Bone meal, bone char, monocalcium phosphate and rock phosphate are the common phosphorus supplements for sheep and cattle.

Pregnancy disease, which occurs late in pregnancy and attacks ewes between 3 and 6 years of age carrying twins and

triplets, was thought for a time to be due to calcium or phosphorus deficiency, but opinions are changing. There may be a hereditary weakness to the disorder but whatever the cause, it represents a failure in normal carbohydrate metabolism; and because it appears similar to acetonemia in cattle, molasses is sometimes fed or sugar injected. It does seem however, that the disorder is less prevalent where good rations including alfalfa hay are provided.

Students of nutrition are displaying a new interest in the use of copper in feeding sheep. Feeders paid little attention to it until the increased prevalence of stiffness in lambs was noticed after the vermifuge, phenothiazine had partially displaced the old favourite copper sulphate. There is good evidence that the stiff lambs respond favourably to the feeding of copper sulphate and for preventive or remedial purposes, one pound of copper sulphate mixed with 500 pounds of loose salt, is recommended.

Iodine. Sheepmen in Canada must provide iodine, especially for pregnant ewes during winter months. Goitred lambs will be the penalty for neglect. Commercially iodized salt with its 0.023% potassium iodide, if stabilized and fed throughout the year, may be adequate. But the safe alternative is to iodize the winter's supply using potassium iodide at 2 ounces per 100 pounds of loose salt.

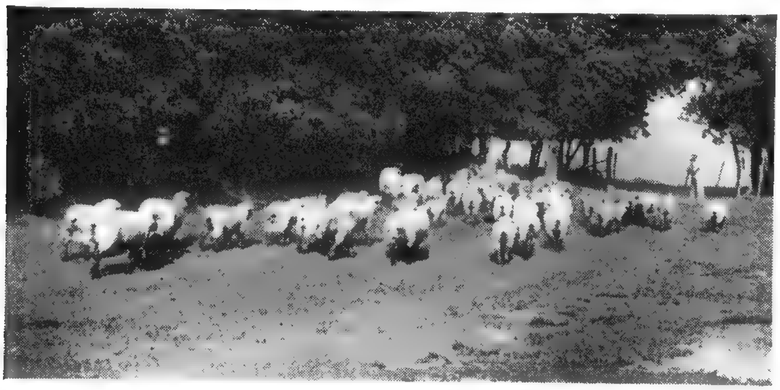
Cobalt. Evidence of a need for supplemental cobalt in some sections, is increasing. The University of Alberta found that when sheep were maintained for relatively long periods on non-legume roughages, a nutritional debility developed which was corrected by the addition of cobalt chloride solution to the salt, 5.7 grams of cobalt chloride to 100 pounds of salt. The Alberta workers did not conclude a general cobalt deficiency among range and farm flocks but under the conditions of the experiments, the provision of cobalt improved reproduction and milk secretion and reduced ewe mortality. They considered it likely that ewes living on soils rich in cobalt would get sufficient of that element in a natural way.

Vitamins. Much of the most recent knowledge of nutrition revolves around the various vitamins. It is, however, a relief to the sheep men that not more than one or two of these will be found lacking in natural rations for sheep. Vitamin A, perhaps, will be the first in point of practical importance to the sheep man, although insufficient vitamin D could be the cause of some cases of rickets, stiffness and crooked legs in lambs.

Vitamin A. The vitamin A factor is as important to the health of the animal as it is to its growth and reproduction. Sheep

inoculated artificially with infection have withstood the infection better when fortified with vitamin A. Normal body reserves of this vitamin are depleted slowly but when there is a deficiency in the pregnant ewes' feed for a long period, lamb mortality is likely to result. There has been wide-spread evidence of vitamin A deficiency among sheep flocks in the spring of some years, notably in 1943 which followed a winter in which a great deal of weathered feed was used in Western Canada; night blindness in the ewes, abortions, weak lambs and blind lambs occurred. Such conditions justified the use of some fish liver oil in late winter or early spring when body reserves were low or depleted.

Vitamin A is one reason why green grass is a valuable feed and it is an important reason why hay with a good green colour is worth more than brown or pale hay. Indeed the green colour in hay is worth real money to feeders, just as salt, potassium iodide or bone meal is worth real money.



An attractive farm flock of Oxfords

Better Roughage. Too much mature fodder and not enough immature forage and hay is one of the chief weaknesses in rationing sheep in this country. It is common knowledge that protein and phosphorus diminish as the plant matures. Growing plants can't be prevented from maturing but there is nothing to prevent the sheep feeder from recovering more hay when it is still rich in protein, phosphorus and vitamin A. The harvesting of hay and roughage has been taken too casually, with too little thought given to the major changes which take place in plants as they mature or as the hay is exposed to rains or weathering.

Alfalfa Hay. Probably no single feed is capable of improving sheep feeding programmes as effectively as alfalfa hay. Alfalfa

pasture is not popular with sheepmen on account of the bloating hazard, but alfalfa hay, well cured, can obviate the need for protein supplements, phosphorus supplements and vitamin A supplements. It is one of the best possible balancers in sheep rations; it can make home-grown feeds almost completely adequate; it can make for better fertility and better milk supply. The sheep farm is better equipped when it has a field of alfalfa.

Poisonous Plants. On account of their close grazing habits and their fondness for variety in grazing, sheep are more likely to be victims of poisonous plants than other farm animals. It is important therefore, that the sheep man be familiar with the dangerous weeds. The trouble will arise more readily in overgrazed pastures where the sheep cannot help but eat quantities of the weeds.

CHAPTER XXIV

THE PRACTICE OF FEEDING SHEEP

Sheep production follows a regular cycle of annual events with everything dating from lambing. Feeding methods and feeding problems follow the same order on the shepherd's calendar, year after year,—flushing, winter feeding, lambing, summer feeding, weaning and lamb fattening. Feeding practices will be considered in that order.

Flushing. Following weaning in the autumn, it is customary to place the lambs on good grazing to prevent a setback, and the ewes on dry feed to retard milk secretion. Stubble fields may well provide the principle feed for the breeding flock for a period in the fall. It is about that time that farm flocks are culled. After the ewes have quite dried up and the breeding season is close at hand, it is standard practice to condition them for breeding.

This conditioning of the ewes for breeding is called flushing. It is based upon the principle that ewes gaining in condition at the time of mating will release more eggs to be fertilized, and thus conceive a higher percentage of twins than ewes which are on maintenance. Even fat ewes which are being maintained in high fit will not produce as many twins as the lean ewes which are "picking up". Twin lambs are usually more profitable than singles and flushing may be expected to increase the lamb crop by 15% to 20%. It also stimulates breeding activity and causes the ewes to come in season more quickly and settle more readily,—all of which results in more lambs being dropped about the same time. This more generous feeding of the ewes to have them thrifty and gaining steadily, should begin two or three weeks before the breeding season and might consist of supplying better pasture or a special crop such as rape. Second crop clover or alfalfa would prove sufficiently nourishing and stimulating. Both rape and alfalfa are excellent fall pastures for sheep and lambs but the sheep man should remember the danger of bloat when sheep gorge on these, or eat much of them when they are wet with dew or rain. In some instances it will be more practical to carry some suitable crop to the ewes, e.g., green alfalfa, or

Champion Oxford Ram, C.N.E., 1937. Owned by James A. Telfer, Paris, Ont.

Champion Dorset Horn Ram, R.W.F., 1937. Owned by Cecil Stubbs, Wheatley, Ont.

Champion Cheviot Ewe, R.W.F., 1933. Owned by Floyd Ayre.

Champion Suffolk Ram, R.W.F., 1937. Owned by Beath Farms, Oshawa, Ont.

rape, or cabbage. Still another alternative is to provide the special feed in the form of grain, giving about one-half pound of oats or oats and bran per ewe daily.

Ewes which have not been on good pastures through the summer and autumn months would react favourably to the provision of some bone meal at this season; one part of bone meal and three parts of loose salt is a good mixture to place in hoppers for the band.

Feeds For the Ram. The ram as well as the ewes, may need conditioning for the breeding season. He should be in a vigorous condition but not too fat. In most cases, a pound of grain a day, in addition to good roughage, will be beneficial by way of preparation and extra grain during the breeding season would be justified if there were opportunity to feed it. While it is the practice on many farms to allow the ram to run with the ewes constantly during the breeding season, there are some sheep men who allow the ram to run with the flock during the day but confine him to barn at night. This latter practice permits of the provision of extra feed as well as more rest and is likely to extend his effectiveness. A grain ration of two parts of oats and one part of bran, or, five parts of oats and one part of linseed oil meal, is suitable for the ram at any time and might be provided at the rate one to three pounds daily when there is opportunity during the breeding period. It should not be forgotten that the ram needs salt too.

Winter Feeding. Winter feeding should be planned to ensure vigorous lambs because a large crop of good lambs is the very basis of a successful sheep enterprise. Winter feeds, therefore, must provide for a little more than maintenance. Good roughage will meet that need and when it is fed to ewes in good condition, no grain will be needed until late in pregnancy. On the other hand, thin ewes or ewes feeding on limited or mediocre roughage would benefit by half to one pound of grain daily. Oats are a favourite grain for sheep and need not be ground.

Wintering ewes need about 2½ pounds of total air-dried feed per 100 pounds of live weight. Accordingly, a ewe weighing 140 pounds would need 3½ pounds of hay and grain daily. Farm ewes which are required to make the best possible use of pasture are likely to consume about 750 pounds of hay and 50 pounds of grain in addition to grazing each year.

Roughages. The roughages from which sheep feeders make their winter selections are legume hays, grass hays, oat sheaves, cereal straws, silage and roots. A legume hay, alfalfa or clover, is the best possible foundation for the winter rations; its high

protein and balancing qualities will help to ensure strong lambs and good milk supply. Even a fraction of the roughage ration as legume hay, one quarter or one third, would be helpful. Grass hays are next best. Oat sheaves are useful in mixtures but oat sheaves by themselves are not conducive to the production of strong lambs. The cereal straws have low net feeding value at any time and should not constitute more than a small part of the sheep's ration unless there is compensation in the form of grain. Coarse stemmed roughages and slough hay are not very suitable for sheep, nor is timothy hay, a domestic product, favoured for sheep. The mixing of low grade and high grade roughages will be simplified if they are processed by means of a straw cutter or cutting box.

Silage and roots are excellent for wintering ewes when fed in small amounts. Neither is essential however, and when fed in large amounts, there is a danger of producing big, flabby and weak lambs which will be hard to save. Two pounds a day of good silage free from mould, or three or four pounds of pulped turnips or mangels is justified during pregnancy, but larger amounts would be better if used after lambing rather than before.

Rations. The following winter rations are fairly representative of major types and may be considered as adequate for pregnant ewes of 140 pounds:

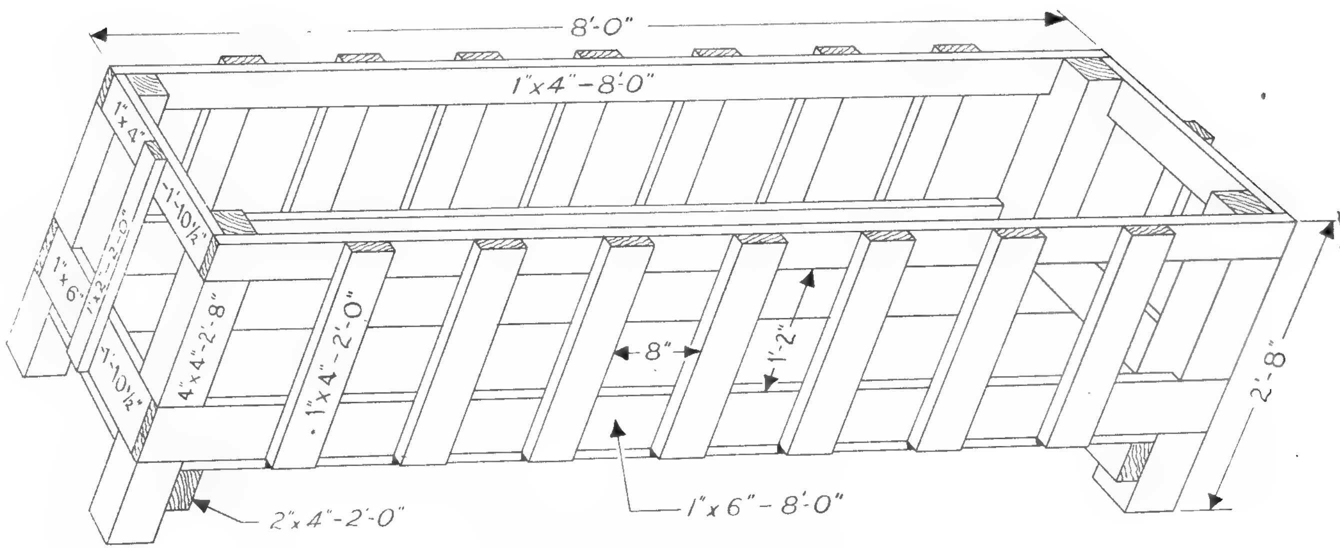
A—3 lb. clover or alfalfa hay.
2 lb. silage or 3 lb. pulped roots.

B—2 lb. clover or alfalfa hay.
1 lb. oat straw.
½ lb. grain.

C—2 lb. legume hay.
1½ lb. grass hay or oat sheaves.

D—2 lb. grass hay such as prairie hay or brome.
1½ lb. oat sheaves.
(In this ration which includes no legume hay, it is more important that some high protein grain feed be provided during the month before lambing.)

Feeding Methods. Because of the great stomach capacity charasteristic of ruminant animals, feeding twice daily is adequate. To ensure exercise, there is some advantage in feeding the wintering ewes some considerable distance from their shelter; and with long roughage, there is no harm in scattering the feed in order to make the ewes rustle around more. When feed racks are in use, they should be constructed with perpendicular rather than sloping slats; this lessens the amount of chaff and foreign matter which will fall into the fleece.



A Combination Feed Rack For Sheep

Roughages may be processed by means of a cutting box. This reduces waste and facilitates mixing. Otherwise there is no advantage. As long as the sheep's mouth is sound, there is no need to grind grains, except perhaps to crack barley or wheat.

Supplements for Wintering Ewes. There is some advantage in using loose or granulated salt instead of the block salt, as the ewes are more likely to take all they need of the former, but may tire before they get enough of the latter. But either block or loose salt meets the need.

Where commercially iodized salt is not fed throughout the year, or when the stability of the iodine in the commercial product is questioned, feeders should take steps to iodize the salt to be used by the ewes for the winter months. Without such precautions, goitred lambs and heavy losses may follow. It is a simple matter to iodize salt for ewes; two ounces of potassium iodide dissolved in a pint of warm water and sprinkled over 100 pounds of loose, dry salt, will do it. This is then placed before the ewes.

With good quality legume hay in the winter rations, other supplements may not be needed, but otherwise there may be need for a supplement of phosphorus and vitamin A. The former can be supplied in the form of bone meal, bone char or monocalcium phosphate. Extra vitamin A can be provided by an allowance of a standard feeding oil.

Water. Contrary to opinions held in some quarters, sheep do require water, even when there is snow on the ground. The careful shepherd will not fail to provide all the water the ewes will consume regularly.

Feeding at the Lambing Season. Where ewes lamb before going to grass, they should get some grain or some extra grain, from one half to one and a half pounds daily, as lambing time approaches. Oats and bran are among the most useful grain feeds to use at this time. Oil cake meal at the rate of one-eighth to one-quarter of a pound is sometimes fed prior to lambing if no legume hay is in use, although it is more commonly used as a part of the ration to milking ewes.

There is an advantage in having ewes in a laxative condition for lambing and bran and oilcake are useful. But heavy grain feeding at that time will create additional udder troubles. A slight and temporary reduction in feed is appropriate.

After a ewe has lambed, the shepherd is confronted with new feeding problems. The ewe will need more feed and if all is normal, she should be up to full feed and getting one and a half pounds of grain and plenty of good roughage three or four days after lambing. The lamb may require special attention; if it

should be too weak to nurse, it should be given a few teaspoonfuls of warm milk from a bottle every hour until it has gained sufficient strength to stand and suck.

The importance of the first milk or colostrum to the young lamb can scarcely be overestimated any everything should be done to ensure that the lamb gets it by natural or artificial means. The shepherd should trim any tags of wool from around the udder to prevent the lamb or lambs from sucking and swallowing them. Wool balls in the stomach cause serious indigestion.

Feeding the Orphan Lamb. When it becomes necessary to rear a lamb by hand one should follow natural conditions as closely as possible. If it can be arranged, the lamb should get ewe's milk from a recently lambed ewe for the first day or two of its life, getting one ounce every two hours. The switch to cow's milk can

Orphan lambs require special care

then be made with less risk. A bottle with nipple is the standard method of feeding the orphan.

Ewe's milk is rich in fat, about 6% or more, and it follows that the milk selected for the lambs should be from a cow having a high test. In a 1943 experiment at the University of Saskatchewan, lambs on 6% butterfat milk outgained those on 3% milk and were more vigorous. It is better to use the milk from a single cow.

The best rule is to feed often and not much at a time. For the first two or three weeks, there should be at least four feedings a day, four hours apart. The allowance per feed should be increased gradually from three to eight ounces. After three weeks of age, three feeds of milk per day and totalling from two to three pounds, are recommended. All milk fed should be close to body temperature or around 100°F. Cleanliness is essential to prevent digestive troubles and scours. A constipated lamb should be given a teaspoonful of castor oil and the same treatment along with reduced milk will help to check scours.

The lambs will show an interest in green forage and grain feed at three or four weeks of age. Bran and rolled oats are suitable for such lambs and green alfalfa is the best possible forage. Hand raised lambs will often wean themselves from milk at three months or less.

Summer Feeding. The cheapest and best feed for sheep is good pasture and the fullest use should be made of it. If pasture conditions permit, it is a good plan to get the newly lambed ewes and their offspring on grass a few days after lambing. Otherwise the ewes will require special care and liberal allowances of grain in order to support milk flow. A good pasture offers the most sanitary surroundings for the lambs and experienced sheep owners are very insistent that the band be on grass when the operations of castrating and docking are performed at ten days to two weeks of age. Furthermore, good young pasture will stimulate milk production better than any feed; indeed, it is to be remembered that the weight and value of the lambs in the fall are very largely determined by milk. Sheep do best on upland grazing.

With good pasture, the nursing ewes need no other feed except salt and water. The provision of an abundance of clean water convenient to the grazing is a first essential in summer management. It should not be overlooked that sheep relish a change of pasture from time to time. A rotation of grazing will also help to control parasites.

Lambs will start nibbling at grain at an age of four weeks, and bigger lambs will result if a mixture of crushed oats and

Lambs in a feed lot

Courtesy Ontario Live Stock Branch

Prize pen of Southdown lambs. Owned by J. D. Patterson. Richmond Hill, Ont.

bran is provided for creep-feeding. Lambs are weaned at four to five months, at which time the ewes should be placed on dry feed until the drying-up process has been completed. At the same time the lambs should go to good feed in order to avoid a set-back.

Feeding Market Lambs. It is the aim of many farm flock owners to market a high percentage of fat lambs at weaning time. If the lambs inherit good mutton type with early maturity and receive lots of milk, they may reach 80 pounds at 4½ months and be sufficiently fat for immediate slaughter. Such lambs are usually most profitable.

Other lambs, not intended for breeding, should go into the feed lot soon after weaning to be grain fed until ready for market, at 80 to 90 pounds. The feed lot or feed yard should restrict

Feeder lambs, a pen of winners at a Canadian Feeder Show in 1944

the lambs to fairly small quarters because more than moderate exercise is not consistent with economical gains. After being removed from the ewes or when first placed in the fattening pen, it is quite safe to give the lambs all the good hay, mixed grass and legume hay, which they will clean up. They will each eat two to two and a half pounds of hay per day. A foot of trough space is needed for each lamb.

Feeding grain to fattening lambs calls for careful attention or a high death loss will result. It is essential that the quantity

be increased gradually. Whole oats make a good starting grain; and for those lambs which never received grain from a creep prior to weaning, it is suggested that one-eighth of a pound of grain per lamb per day is enough for the start. As a precaution against digestive troubles, bloating and deaths, it is wise to take four weeks to bring the grain up to "full feed" which is about one and a half pounds per lamb each day. Some feeders get up to two pounds per day but it is a risky level. Heavier grains like barley should replace part of the oats and then most of the oats. Water should be provided at least twice daily or better at all times and salt should be available constantly.

A daily gain of one-third pound in feed lot lambs is considered an excellent flock average. Generally, gains range between one-fifth and one-third pound per lamb per day. Wether lambs make slightly faster gains than ewe lambs. To bring a 65 pound lamb to marketable finish at 85 pounds, the feeder should count on two and one-half months of feeding and a feed expenditure of approximately 100 pounds of mixed grain and 140 pounds of hay. Mortality in feed lot lambs averages between 2% and 4%; such losses usually reflect feeding and management methods more than disease; losses are highest with heavy feeding, especially where not enough roughage is included in the feed.

Courtesy Ontario Live Stock Branch

Prize Southdowns. Owned by J. D. Patterson, Richmond Hill, Ont.

CHAPTER XXV

NUTRITION OF HORSES

Inasmuch as the horse is a herbivorous animal with a simple stomach, its position is different from that of any other barnyard animal. Its relatively small stomach containing about four gallons is quite a contrast to the very large stomach organ in the cow; but by way of partial compensation, the horse has a large storage space farther back, in the caecum. The result is that the horse is able to digest fibrous feeds with a good degree of efficiency although not quite as effectively as the cow or sheep. It follows too, that the cow, with a 45 gallon stomach, can do well on two feeding periods a day, but the horse, with much more limited capacity, demands three feeds daily.

In studying the digestion and nutrition of the horse, there is a temptation to speculate about the nature of the diet eaten by the prehistoric forms. At least, the presence of canine teeth, the small stomach capacity and the multi-toed feet which characterized early forms were not typical of herbivorous animals. But while feeds eaten by Eohippus or the dawn horse remain among nature's secrets, certainly the modern type is a confirmed vegetarian.

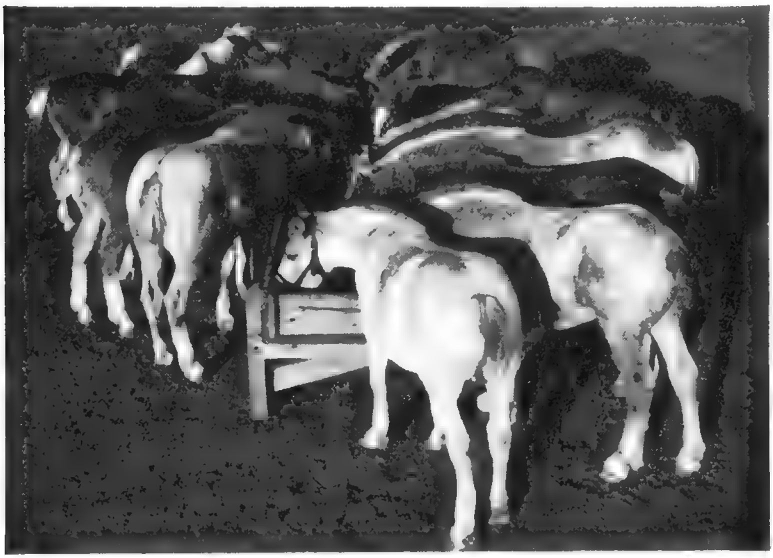
Feed for Work. Work is accomplished by the contraction of muscles, in the course of which action, energy stored in those muscles is utilized. The restoration of such energy to permit continued physical activity, depends upon the oxidation of food nutrients, mainly carbohydrates and fats. The need for protein in performing work is surprisingly low, only a little greater than in animals at rest. There must be at least slight wear of muscles due to work, but it is believed that some of the broken down protein is re-utilized. Only if feed supplies are insufficient and the animal becomes run down, will body proteins be used. Consequently the conclusion seems warranted that large amounts of protein are not needed by working stock.

Actually, the feed requirements of working horses are not greatly different from those of fattening animals; the chief needs being an abundance of carbohydrates as a source of energy, and a certain small amount of protein to meet body needs and ensure

against depression of digestion. A ration composed of oats and grass hay has a nutritive ratio of about 1:10 and this seems satisfactory.

The appropriate amount of feed depends upon the work being done. Feeding standards have very limited use in rationing working horses; they may serve as general guides but due to varying conditions of speed of work, hours, load, grade, roughness of road bed, traction, fatigue, etc., it is impossible to be specific. It becomes necessary to select a suitable ration rich in Feed Units or carbohydrates and feed enough to ensure against loss of weight.

Idle horses which have reached maturity and are not being fattened, require little more than a maintenance diet. In the interests of economy, idle horses are commonly required to forage for themselves.



Pure-bred Belgian colts at the feed trough on an Illinois farm

Feed Requirements for Growth and Nursing. Growth in young horses is rapid and often there is need for more protein and mineral matter than is provided in the course of barn feeding during winter months. The nutritional demands for muscle and bone development must be great in any animal which is born at a weight of 125 pounds and weighs 800 pounds at one year of age. A young horse may be expected to reach one-half of its

mature weight at one year of age and 75% of its mature weight at two years. It can be expected therefore, that a colt will be more susceptible to nutritional troubles during its first winter, than at any time prior to being broken to harness. Therefore, growing colts should be fed with special care.

Nursing mares have roughly the same nutritional needs as milking cows, but mares do not reach such high planes of production as specialized dairy cows.

Nutritional Deficiencies. Deficiencies which might be traced to the lack of protein or some mineral or vitamin material, are not common in mature horses. Emaciation due to insufficient metabolizable energy or simply to not enough feed is a more common condition and will account for a lot of thin horses about the end of the seeding season each year. Rations comprising good roughage and a single grain are in wide use and, on the whole, are satisfactory.

Nevertheless, deficiencies occur. Perhaps the most widespread is caused by the horse perspiring at work and thus losing a good deal of salt in the sweat. Unless those body losses are made good, physiological processes will be handicapped. It is therefore necessary to supply common salt.

Pregnant mares should receive supplemental iodine, and very often fast growing colts are victims of calcium and phosphorus deficiency and perhaps vitamin A deficiency. Very little is known about the vitamin requirements of horses, especially the possible losses due to heavy work and sweating. But in young horses, a lack of vitamin A could contribute to unthriftiness, retarded growth and probably some irregular types of hoof growth. Some alfalfa hay in winter rations for colts will help to offset various nutritional deficiencies, but when that is not available, some carrier of calcium and phosphorus would be a useful addition to the rations.

Horsemen should know that bran is rich in phosphorus and for that reason, it has considerable value for colts and other horses. But when bran is fed very heavily an unfavourable balance between phosphorus and calcium, referred to as "bran disease" may occur and therefore a reduction of phosphorus in the ration or an increase in calcium is called for.

Digestive Disorders. The horse's digestive system is more sensitive than that of the cow or sheep. Once in a while the cow will develop an annoying case of impaction but colic in horses is comparatively commonplace. The artificial conditions created by the heavy muscular work done by the horse may account in part for the difference, but not altogether. Even foals are not as free

from digestive disorders as calves; foals reared by hand are more susceptible than pail fed calves to the troubles which follow infection or overfeeding.

Oats which have heated or any feed which has deteriorated by spoiling should not be fed to horses. Dusty feeds make horses cough. All in all, horses are more susceptible to dusty or moulded or spoiled feeds than are cattle, sheep or pigs.

Some of the colic and indigestion in horses is certainly due to careless feeding and overfeeding. Horses do not possess the same good judgment and restraint which characterize the mule. A mule eating from an open bin will stop when it has had sufficient, but a horse will gorge itself. Where a heavy grain like barley or wheat is being fed to horses, it is vital that rationing be on a weight rather than a measure basis. A gallon measure of oats weighs a little over 4 pounds while a gallon of barley weighs nearly 50% more than that and a gallon of wheat, 75% more. It can be seen, therefore, that a stomachful of wheat will weigh 75% more than a stomachful of oats. This explains why horses which break into a granary of wheat and eat their fill have much less chance of surviving than those which get a fill of oats.

It is during the period of seeding operations in the spring that colic in working horses is most common. The observant horseman usually detects approaching disorder a half day or more before the trouble is acute. In such cases, the colic can usually be avoided. If a horse appears strangely sluggish in the course of the morning work and is indifferent about its noon-hour grain, the best thing to do, if at all possible, is as follows: take away the grain feed and most of the hay; remove harness and leave the horse in the barn for the afternoon; place a pail of water before it and give it a bran mash at night. With this treatment, there is a fair chance that instead of a sick horse during the night, the animal will be the first one to issue a call for its oats next morning. It's easier and cheaper than medicines.

If and when one of those digestive disorders known as colic develops, a veterinarian should be called at once. But where that is not possible, this old time remedy may prove effective; two teaspoonfuls of soda and one teaspoonful of ginger in a pint of cold milk or water. This should be given as a drench and repeated in an hour if thought necessary.

Water. Mistakes in watering practices have done much to reduce the efficiency of horses. There is an idea in some quarters that horses should not be watered after receiving their feed and consequently they are sometimes required to begin a half-day's work feeling the need for a drink. The only possible reasons which could be given for such a policy are, first, that

the water would tend to wash some of the finer particles of feed into the intestine before they were exposed to the digestive agents in the stomach, and second that a big drink of water on top of recently eaten feed would distend the stomach and press upon the diaphragm causing the animal to be short of breath. Actually neither of these theories is acceptable because most of the water consumed will not remain long enough in the stomach to interfere with respiration and the negligible amounts of feed carried into the intestine can be acted upon by intestinal juices.

The advantages of water after a meal, if the horse wants it, are likely to far outweigh the disadvantages. There are horse users who have observed that their horses work better and with less fatigue when water has been offered to them in the middle of the half day in the field. For this purpose, a trough and water tank on wheels might be taken to the field where the horses are at work.

Feed Costs. The degree to which feed costs and other costs can be kept low will determine in large measure, the popularity of horses in agriculture. More extensive use of grassland in both winter and summer seasons would help reduce costs.

A study of costs of horse operation in two Manitoba districts, Red River Valley and Riding Mountain Fringe, was conducted by Dr. H. B. Sommerfeld (*Economic Aspects of the Horse Industry in Western Canada*) in 1931. In the Red River Valley where 148 farms were studied, the roughage and bedding allowance per horse unit was 7,545 pounds, the concentrates consumption was 3,473 pounds, and the total feed cost per horse unit per year, with a $3.27 charge for pasture, and $42.51. This was 49.9% of the total cost for the year, which included 31.9% for labour, 8.8% for housing, 7% for miscellaneous and 2.4% for depreciation. In the other area where 226 farms were studied, the charge against each horse unit for feed and bedding amounted to 7,122 pounds of roughage and bedding, 2,907 pounds of concentrates and $1.92 worth of pasture. The total feed cost in this case was $31.04 per year. The total number of hours worked per year for each horse were 772 in the Red River area and 770 in the Riding Mountain Fringe. Considering the period of work in a year, it must be perfectly obvious that more extensive use of grazing would reduce costs greatly.

CHAPTER XXVI

THE PRACTICE OF FEEDING HORSES

If horses are to retain a position of importance in Canadian agriculture, economy in rearing and feeding is imperative. According to surveys, the cost of keeping a horse for a year is often as great as its market value and on some farms costs run twice as high as on others. More and better use of grassland in both winter and summer, offer the best hope for further economies.

Idle Horses. Horses not in use during winter months are usually carried over that period of idleness by one of three methods; they are

(a) turned out to rustle

(b) confined to barn and barn-yard

(c) have freedom of fields during day and are stabled at night.

To confine horses to barn and barn-yard for the winter months is the most costly plan. If those turned out to rustle have access to native grassland or straw stacks, the cost of wintering will be low and the animals will have a good chance of maintaining condition. The plan of turning horses out to rustle their feed during the day and stabling them at night when a little extra feed is given, has a lot in its favour. In any case, one of the greatest drains on the feed during winter maintenance is body heat, and the cheaper roughages can supply that effectively. Salt and water are essentials.

Those idle horses being "roughed" through the winter will want some conditioning before going to work in the spring. That calls for some grain feed for three or four weeks before the heavy work begins.

Quantity of Feed for Working Horses. Horses at regular heavy work require daily about,

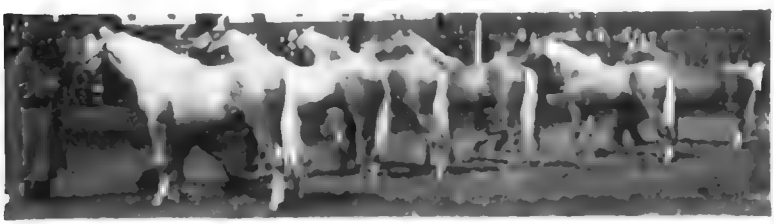
1¼ to 1½ pounds of hay per 100 pounds live weight.

1 pound of grain per 100 pounds of live weight.

For the 1,600 pound horse, that would mean 20 to 24 pounds of hay and 16 pounds of grain each day. Instead of dividing the

A dependable farm power unit

This pure bred Belgian team established a new world's record in 1944 with a tractive pull of 4,175 pounds. Bred, raised and driven by L. J. Smith, Hedrick, Iowa.



A class of Palominos at Edmonton Spring Show, 1945

ration into three equal feeds, it is good practice to feed nearly half of the total hay at night when the horses will have plenty of time to fill up on roughage, and nearly half of the grain feed at noon when the feeding period is inevitably short. Some successful horsemen support the principle of one-quarter of the grain and one-quarter of the hay at the morning feed, one-half of the grain and one-quarter of the hay at the noon feed, and one-quarter of the grain and one-half of the hay at night. Fattening horses, if they have good constitutions and good appetites, may be fed as heavily as working horses. However, there is always greater danger of disorder when idle horses are heavily fed. Normally, it is good practice to reduce grain feed to 25% or less for working horses during any stretch of idleness, as might occur at week-ends.

Preparing the Feed. If horses have good teeth and are not inclined to bolt their oats, such grain can be fed whole. Otherwise, rolled or crushed grain gives at least a 10 per cent better return than whole grain. Processing in this manner also helps to destroy the power of germination in weed seeds which otherwise might pass through the digestive tract. In no case, however, should grains be ground finely for horses.

Cutting or grinding roughage for horses simplifies the problem of mixing feeds and reduces waste but there are no other advantages and under most circumstances the costs involved are not justified. In the case of winter rations for idle horses, where cheaper or plainer roughages are used, there might be justification for cutting with a cutting box but not with any machine which would grind to a fine state.

Feeds are nearly always given dry to horses; two notable exceptions are boiled barley and bran mash. Dry feeds are best for working horses, but boiled barley is a great favourite in fattening idle horses for show or sale, and a Saturday night bran mash will prove beneficial for working horses which are to be idle over the week-end. Four pounds of bran will make a good mash; boiling water would be poured over it and a cover left on the container until the damp mash is cool enough to be fed. With the addition of an ounce of salt, it is ready for the horse. A bran mash given according to this plan would replace the regular grain feed.

Grain Feeds. In Canada the grain which enjoys national favour for horses is oats. That grain is bulky and its physical character seems to suit the horse's requirement. New oats will sometimes cause digestive troubles but in general the grain is very safe. When grain mixtures are prepared for use instead of oats, the 10% fibre content of oats should be imitated.

While Canadian feeders proclaim the superiority of oats for horse feeding, it should not be overlooked that corn is fed extensively in the United States, barley is a common horse feed in parts of the Old World including Arabia from whence came the colourful Arabian breed, and finally that in some years of crop failure on the Canadian prairies, wheat was fed successfully. All heavy grains, of course, must be fed by weight or overfeeding and trouble can be expected.

Still, straight wheat or barley is not favoured by horsemen; one criticism is that when fed alone such grains make horses sweat unduly. But it is entirely practical to use barley or wheat as a portion of the grain ration and there are times when mixing will achieve economies. Equal parts of oats and barley or two parts oats and one of wheat can be endorsed as likely to give complete satisfaction when reasonable care is exercised. Three parts of cracked wheat and one part by weight of unground oat hulls give a grain feed having a fibre content of about 8%; this combination effected substantial economies in feed costs for some horse feeders in the few years prior to 1940. Another substitute for oats is obtained by mixing four parts of ground barley with one of bran by weight.

Of the mill feeds, bran is the one most used for horse feeding. It is too laxative to be used extensively in rations of horses actually at work, but a small amount will have beneficial effects; 10% to 15% of bran in the grain is permissable at any time and the bran mash on Saturday nights, or prior to a sudden lay-off, will be an aid in keeping horses healthy and free from digestive disorders.

Only in small amounts with other concentrate feeds should shorts be given to horses. A little linseed oil meal, up to one pound per day, is a fine tonic for run-down horses and those which are being fitted for show and sale.

For fattening purposes, with show or sale in mind, a grain mixture composed of 40 parts rolled oats, 45 parts crushed barley and 15 parts bran is recommended.

Roughage Feeds. Grass is the best roughage for growing horses and idle horses but for working stock, hay is basic. Timothy hay is the accepted favourite but good prairie hay is a close second in point of suitability. Western rye grass, crested wheat grass and eastern mixed timothy and red clover, are all satisfactory. Oat sheaves are fed extensively in the West but their suitability depends upon the stage of maturity at time of harvesting. If the sheaves are cut very green, they may be "soft", and if very mature their value is little different from that of oat grain and oat straw.

An Arabian stallion, Adounad, property of Mr. and Mrs. Clif Latimer, Vernon, B.C.

Palomino stallion, Jungle Gold, with flat saddle

Legume hays have a place in horse feeding but they should be given in relatively small amounts. Rations for young and growing horses will be improved greatly by some clean alfalfa or clover hay, perhaps 50% of the total roughage. But 50% of alfalfa in the roughage of working horses is the absolute maximum and 25% along with grass hay would be better. The mature horse does not need all the protein supplied by so large an allowance of alfalfa hay and it might throw an added load upon the kidneys.

The cereal straws are not good enough for horses at work. Good oat straw can be used for idle horses in winter but it must be remembered that the net feeding value is low. The best results from straw are obtained when horses run at straw piles; in that way they are able to pick over the feed and reject the less acceptable parts. The good condition sometimes displayed by horses which have been allowed to run at a straw stack, has created an exaggerated opinion about the value of straw. The horse at an average straw stack eats a very different range of feeds than the horse required to consume all the straw placed in its manger. Barley straw, if free from awns or beards, is as good as oat straw for feeding.

Succulent feeds like roots and silage are not a necessity for horses, and will usually represent a more costly source of dry matter than hay. Nevertheless a small allowance of silage or roots may prove a good appetizer during winter months. The position of carrots is rather different however; horses relish carrots and the high content of carotene is considered an aid to health, especially during winter months. Feeders of show horses will find a supply of carrots most beneficial.

An attractive string of draught geldings at Edmonton Spring Show, 1944

Grass Use. No class of animals is capable of making more complete use of Canadian grass than horses. Good grass is nature's best feed for horses as it is for cattle and sheep; but horses can use more grass due to their ability to forage for it beneath a covering of snow. It is well known that if the snow is not too deep, horses will paw and gain access to the vegetation. This is especially important on the Western Plains where many of the native grasses tend to cure on

the ground and thus afford a fairly nutritious feed for horses through the winter and until the green grass comes again.

For reasons of economy and good health, pasture should be used more extensively in horse feeding. Grass is the appropriate feed for idle horses and for working horses it can be a valuable supplement to the regular ration. It is good policy to allow working horses the run of grass paddock for an hour each evening. A horse cannot do heavy work on grass alone; it is too "washy" or "soft", but the evening hour of grazing will provide a wider range of feed nutrients and an effective tonic.

Inter-breed gelding class at Saskatoon Exhibition, 1941

Water and Salt. Salt should be provided regularly for all horses. A lot of body salt is lost in sweat and consequently, horses doing heavy work need salt very much. For stabled horses, one per cent of salt in the grain feed is sufficient and for all others, a block or box of salt should be available to them in paddock or field.

Except when very hot, horses should have all the water they desire.

Feeding the Brood Mare. The mare in foal needs but little special feed or care until she nears foaling time. Regular exercise and enough good feed to ensure vigour and medium condition, are the essentials. Many horse owners work the mares in harness until a few days before foaling which is all right if the mare is in good order and the work does not involve heavy pulling, backing or plunging in mud or snow. There is no better place for a foal to be born than on grass and the mare running on grass will be at her best. But if foaling comes early, i.e. before the grass season, the mare should get a grain ration in which bran predominates for a week before foaling. Bran and oats would be suitable. And some legume hay for several months before foaling will help to ensure a good supply of milk.

Potassium Iodide. In addition to salt for brood mares the one other essential mineral element is iodine. A deficiency of this element during pregnancy is believed to cause weakness in foals at birth. It is recommended therefore that one ounce of potassium iodide be dissolved in a gallon of water and kept in a corked crock; each pregnant mare should be given one tablespoonful of liquid on her feed or in her drinking water each day for the last three or four months of pregnancy. A mare should get at least half an ounce of potassium iodide during that period. (256 tablespoonfuls in a gallon of solution).

The Foal. Foals born on grass enjoy natural advantages in clean surroundings and a more certain milk supply. But if foaling is inside, there are some important points to be kept in mind. After the foal's navel has been disinfected with tincture of iodine or 10% carbolic acid, the young animal should be encouraged and helped to nurse. That first milk, and it alone, meets all the nutritional needs of the new-born. If there is constipation, it calls for two or three ounces of castor oil or a rectal injection of warm soapy water. Should diarrhoea occur, the suggested remedy is a well shaken mixture of ten drops of creolin and two or three ounces of castor oil.

The mare will want to drink soon after foaling and the risk of complications will be lessened if the chill is removed from the water. The foal dropped inside should be allowed out in the sunshine with its mother whenever weather is favourable. That will ensure the better use of bone-making minerals taken in the milk.

If and when it becomes necessary to work the mare while she is raising a foal, the young animal should be left in a box stall in the barn and the mare brought to it at noon and night. Mares coming to the barn in an overheated condition should be allowed to cool off before nursing is permitted. It cannot be stressed too strongly that any mare working and raising a foal requires extra feed and may be given from 16 to 25 pounds of grain per day, depending upon her constitution and milk flow.

Raising Orphan Foals. Occasionally an orphan foal can be given to a foster mother whose own foal is about the same age. If such a mare will respond sufficiently in milk flow to do this double duty, she should be fed accordingly. When the well-known Clydesdale mare, Langwater Jessica adopted the orphan foal, Sylvia, in addition to her own filly, Julia, her grain ration was increased gradually until she was eating as much as 35 pounds of mixed oats and bran daily. It was unprecedented feeding, but the mare was a strong feeder and she responded in milk flow

sufficiently that both foals were chosen to be shown at the Canadian Royal in the fall of 1930, and they stood second and third in a big class.

But it is not often possible or practicable to find a mare to take an orphan foal and the alternative is to raise the young animal on cow's milk. Whole milk should be used for the first month at least and, if possible, from a single cow. Mares' milk contains more sugar and water and less fat and protein than cows' milk. It is suggested therefore, that cows' milk be modified by providing one tablespoonful of sugar and four tablespoonfuls of lime water and enough milk to make a pint. The new-born foal should be given 3 or 4 quarts of this daily. Scours will result if there is overfeeding. A bottle with rubber nipple is used at first, but a foal can be taught to drink from a pail later.

The Clydesdale mare, Langwater Jessica, adopted an orphan foal which she raised along with her own

Half a tablespoonful of cod liver oil should be fed daily. The following feeding schedule is offered as an approximate guide:

Age of Foal	*Amount of Prepared Milk Per Day*	*Frequency of Feeding*
1st week	3 to 4 pints	8 feeds per day
2nd week	4 pints	6 feeds per day
3rd week	5 pints	5 feeds per day
4th week	6 pints	4 feeds per day
5th week and forward	6 pints or more depending on appetite	3 feeds per day

Frequent feeding is extremely important, especially during the first few days. The milk should be warmed to about body temperature (100°F) and there should be the usual provisions for exercise and sunshine. When the foal is a month old, the sugar may be dropped from the milk formula and a shift to skim milk started. Other feeds including grass and a little meal comprising crushed oats, bran, and linseed oil meal should be made available as soon as the foal shows an interest in them.

Growing Colts. Foals are weaned at 5 or 6 months of age. They should be started on moderate amounts of grain and roughage long before weaning in order to relieve the shock of that change in diet. And incidentally, the halter-breaking process should also be accomplished at that early stage.

The first winter is a critical period in the life of a growing horse. A lot of colts are underfed and some are overfed in those months. Neither is good. It has long been the policy of the Scottish breeders to feed the young horses rather sparingly with the idea of securing harder hocks and cleaner bone. That may be perfectly sound and preferable to high fitting, but still, nourishing rations are necessary to provide for development. Feeds rich in protein and mineral are appropriate. Two parts rolled oats and one part of bran is a good mixture for colts either before or after weaning and a little linseed oil meal, 10% to 20%, will benefit them, especially after weaning. In most cases, about half a pound of grain mix per 100 pounds of live weight can be fed safely. From 20% to 50% of alfalfa or clover hay in the roughage will help by supplying additional protein, mineral and vitamin substances. It is of prime importance that the growing colts get exercise, at least 4 or 5 hours in an open yard regularly unless severe winter weather prevents it.

Percheron mares and foals "at the gate".

CHAPTER XXVII

NUTRITION AND FERTILITY

Failure to breed and irregular breeding account for heavy losses in cattle and other live-stock. Probably dairy cattle present the most marked problems and surveys have shown that reproductive failures represent the chief single cause of loss. Fully 25% of disposals in dairy herds revolve around breeding troubles. The output of minerals and other constituents in the lactations of heavy producers is very high and depletion of body reserves is thought to be responsible for at least some of the breeding failures.

There are many forms of sterility which are definitely within the veterinarians' sphere and other forms which the good herdsman should know how to prevent; only those forms of breeding failure which come under the influence of nutrition, will be considered here. True, it may be impossible to completely separate the two types and it is also impossible to definitely state how much of breeding troubles is due to malnutrition. Time will tell if a nutritional inadequacy accounts in any part for contagious abortion infection and the breeding troubles that go hand in hand with that disease. Time alone will tell the extent to which the optimum intake of vitamin A in calfhood influences resistance to such an infection as contagious abortion and thus will improve breeding performance. Time will tell more about relationships between breeding efficiency and intake of mineral substances like calcium, phosphorus and iodine.

What is the present evidence of a relationship between failure to breed and nutrition? Some would have it that there is "abundant evidence of the association of deficiency of mineral matter with the condition of sterility." That may be putting it strongly but from many parts of the world there comes evidence of a connection between nutrition and breeding failure. A deficiency of phosphorus in the pastures of South Africa is believed to be a major cause of unsatisfactory reproduction there, and in some parts of England a lime shortage is blamed. Similarly there is the rather common claim that an iodine deficiency will contribute to breeding difficulties and from various parts of the world it is reported that where simple goitre is common, breeding difficulties are greater (*Orr, J. B. and Leitch, I. Iodine in Nutrition, 1929*). Some of Britain's best nutrition workers endorse rela-

tionships of this kind but there should be caution in stating the extent to which the great range of breeding troubles can be thus accounted for.

The live-stock husbandman, however little he may know about the science of nutrition, has made some clearly defined observations. He has observed a substantial increase in the percentage of twin lambs when improved rations were fed to the ewes prior to the breeding season; the practice of "flushing" has the effect of stimulating ovulation. The same practical observer concluded that either starvation or overfeeding will influence breeding performance unfavourably. Undernourishment, such as occurs in times of crisis, famine, war or severe drought, is always attended by diminished fertility. Where severe droughts have occurred, it has been noted that oestrus activity and heat periods were often suspended. The effect of overfeeding is evidenced by the poor breeding records of show herds where fat females fail to settle and the males are slow and uncertain. Obesity sometimes produces a permanent sterility.

Breeding performance may often reflect the adequacy or inadequacy of protein material, both in kind and quantity. When one has witnessed feeding practices and conditions across Canada's farming country, it may not be too much to suppose that reproduction in farm animals would be in a better state if the protein part of rations were improved. It has been noted recently that protein at optimum levels is a stimulant to breeding, especially in males.

The view has been presented a number of times, notably by Hart (*Hart, G. H., The Scientific Principle of Nutrition With Particular Reference to Percentage Calf Crop in Range Herds, Eleventh Int. Vet. Congress, London, 1930*) that much of the breeding trouble in range herds is attributable to low phosphorus; it is pointed out that rations low in phosphorus and having a low calcium-phosphorus ratio, tend to interrupt the normal ovarian cycle and lengthen the intervals between ovulations.

Calcium deficiency has been found to be associated with various types of abnormal behaviour in animals; a number of those conditions have been described, rickets, osteomalacia, tetany, etc. It is also reported that this deficiency contributes to the difficulty of getting cows and sows to conceive; and some workers contend that such a deficiency leads to a considerable increase in the number of pigs born dead. The evidence is quite widespread that a shortage of lime in the rations of pregnant sows contributes to milk failure or milk shortage.

Vitamin E was supposed to function in connection with reproduction and was called the "anti-sterility" vitamin. The extent to which it has importance in feeding of farm animals is in

doubt but other vitamins, A, B1, B2, C, and D, are known to play at least an indirect part upon breeding performance. Vitamin C was thought to give favourable results when injected into non-breeding bulls but its exact function is not clear. More recently it has been shown that vitamin A in cows' blood rises and falls in seasons of good and poor breeding performance; furthermore, shy breeding cows were found to have less vitamin A in their blood than the regular breeders.

True, there have been many trials which appeared to show a favourable response in breeding, following the use of some particular supplement such as potassium iodide; no doubt such should be regarded as significant, but whether the supplemental substance had a specific effect upon the reproductive organs or whether the use of such supplements simply improved physiological co-ordination in the organism, is a question which may be debated. It is the physiologist's opinion that to interfere with metabolic activity is to change the normal functioning of various systems of the body and when the reproductive system is affected by deficiency, reduced fertility may well be the result. It has been pointed out too, (*Imperial Bureau of Animal Nutrition, Nutrition in Relation to Reproduction with Special Reference to Sterility in Farm Animals, Nov. 1932*) that the uterus of the non-pregnant cow contains bacteria which are normally quite harmless but are capable, under unfavourable conditions such as might be established by a poor diet, of becoming pathogenic. It will be recalled that vitamin A has a direct bearing upon the resistance of mucous membranes to infection and thus upon the defences of the animal body.

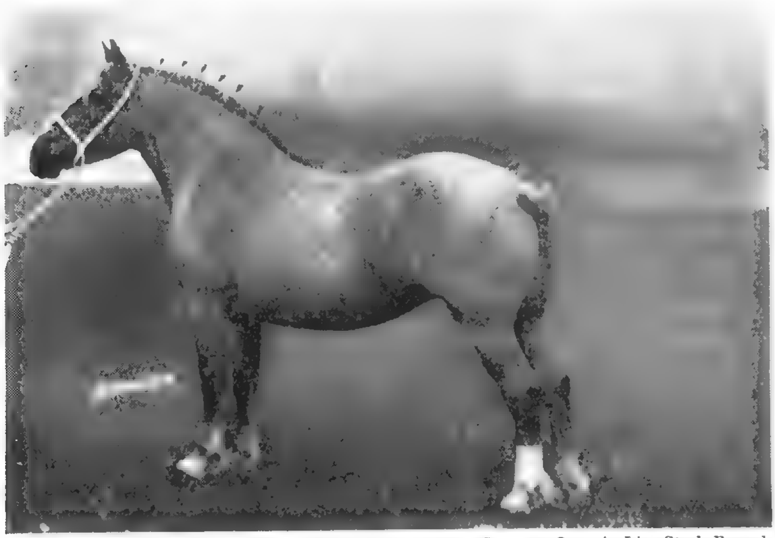
The Imperial Bureau of Animal Nutrition published at the Rowett Institute over which Britain's eminent scientist, Sir John Orr presided, recorded that it has been clearly demonstrated in experimental work with laboratory animals that

> "under-nutrition or malnutrition due to imbalance of the constituents of a diet, vitamins, proteins or minerals, may seriously interfere with normal reproduction . . . It is known that similar defective diets occur with similar results, under extensive conditions in animal husbandry . . . In addition to this direct influence of diet on fertility, there is the other, possibly even more interesting and important, indirect effect through its modifying action on susceptibility to infections. It is known that malnutrition practically determines susceptibility to certain infections."

Reduced fertility may follow a deficiency of a particular element or food factor, or it may reflect malnutrition of a more generalized type. There may have been too great a tendency to place the blame for breeding troubles growing out of faulty nutri-

tion, upon some single substance, phosphorus, calcium, iodine, protein, or one of the vitamins, even though singly, through their absence, they have given evidence of guilt. The stock breeder has been altogether too ready to suppose that by feeding bone meal or iodized salt, or some patent mixture, he can overcome breeding failure in a bull or herd. Instead of regarding the respective substances as having direct effects upon the reproductive system, it would be better to consider them as spokes in a dietary balance wheel, which if absent would contribute to imbalance and a general reduction in physiological tone, and in turn influence reproductive performance.

Giving support to the above is the experience of innumerable cattlemen who have encountered trouble in getting their cows to settle in calf in fall and winter months when feeds were dry and restricted. The use of some specific supplement furnishing a mineral or vitamin substance has not been as successful in correcting these winter breeding troubles as has been a general improvement in rations. And no winter season treatment has produced such dramatic improvement in breeding efficiency as the nutritious spring grass which furnishes a wide range of nutritional substances. Cows which fail to breed in the winter months will frequently conceive readily when given the all-embracing benefits of good grass.



Courtesy Ontario Live Stock Branch

Belgian mare, Brompton Dora. Oka Agricultural College, La Trappe, P.Q.

CHAPTER XXVIII

NUTRITION AND HEALTH

Modern science is showing ever more clearly that proper nutrition plays a great part in establishing health and efficiency in man and beast. Certain disorders like night blindness, beriberi, scurvy, rickets, etc., a somewhat circumscribed group known as deficiency disorders, occur as the direct result of specific dietary shortages. Of equal or greater importance, is the indirect effect of diet upon an animal's ability to resist infections and disorders of various kinds. The latter, although more difficult to appraise, is today receiving the attention of nutrition specialists in many parts of the world. It constitutes one of the most challenging phases of modern research.

Once again it is the lowly rat which has been "doubling" for his fellow creatures of higher orders. It has been well established that rats on a diet which is properly balanced and fortified, can throw off infections which could prove fatal to their undernourished brothers.

Sir John Orr, of world renown as a nutrition specialist and whose services have been invaluable to Britain in times of peace and war, has done much to demonstrate the great health benefits of adequate rations. Sir John and co-workers (*Orr, J. B., Thomson, W., and Garry, R. C., A Long Term Experiment with Rats on a Human Dietary, Journal of Hygiene XXXV, Jan. 1936*) reported an experiment with rats, in which two human diets were studied. One of the diets was approximately that of working-class people in Scotland as indicated by survey, and the second was the same except for the addition of milk and green food. Four generations of the experimental animals were reared and the trial continued for 2¼ years. Both groups were exposed equally to the risk of infection but while the rats receiving the supplemented diet remained healthy, the other lot showed:

"(1) a slightly impaired reproductive rate;
(2) a very marked increase in death-rate due to increased susceptibility to an infection to which all the rats were equally exposed;
(3) a definitely slower rate of growth;
(4) a lower haemoglobin content in the blood;
(5) a clinically poorer condition as judged by behaviour and the state of the coat."

The authors had further comment that should hold significance for the man who feeds live-stock: "Until comparatively recent times, preventive medicine has been concerned chiefly with restriction of the spread of the organismal seeds of disease. Without belittling the importance of better environment and of better hygiene for public health, it does seem that too little attention has been paid in the past to the state of nutrition of the bodies of human beings, the soil in which micro-organisms grow." These remarks must apply to animals and humans alike.

Can one be more specific about relationships between food substances and resistance to disease? Vitamin A has come to be regarded as a food factor of special importance to health. It has been shown that a normal and healthy epithelium is the first line of defence in protecting the body against many infections. Keeping those lining layers of cells in the respiratory, digestive and urinary tracts healthy and resistant to invading organisms is one of the big jobs assigned to vitamin A. Deficiency is the forerunner of various abnormal conditions; besides the eye disease called xerophthalmia, diseases of the respiratory system, colds, sinus infection, skin trouble and infections of the digestive tract have been prevalent. Why is this and how does it happen? In the absence of vitamin A, those lining cells become altered in form and it appears that there is a reduction in what may be regarded as the normal secretions of the cells. These secretions must foster tissue health and there is the possibility that those same juices have germicidal effect. But while such observations are helpful, the precise way in which vitamin A works to reduce the chances of respiratory infections is as yet not clear. The important thing is that it works. The intake of extra vitamins where there is no apparent deficiency, in humans, has been shown to increase resistance to certain infections, a resistance which persists to somewhat the same degree as the reserves of the body persist.

If respiratory diseases establish themselves because of vitamin A deficiency, the disease is not to be considered a deficiency disease although under such circumstances, the deficiency contributed to susceptibility and thus had an indirect responsibility.

Nature's provisions are far-reaching and remarkable. The first milk, called colostrum, is highly fortified with vitamin A, 10 to 100 times richer than the milk of the middle part of the lactation, and for a reason. The "anti-infective" vitamin is of vital importance to the young animal and it now appears that the consumption of the first milk increases resistance to various disorders, including white scours. It was supposed, a few years ago, that the new milk contained anti-bodies that "stepped up"

resistance but the modern view is that resistance is gained mainly through the food factor, vitamin A.

In poultry, as in the higher animals, there is evidence of an increased resistance growing out of nutritional sufficiency. At Pennsylvania (*Murphy, R. R., Hunter, J. E. and Knandel, H. C., Poultry Science XVII, p. 377*) pullets on adequate diets showed distinctly better resistance to caecal or "bloody" coccidiosis; the feeding of cod liver oil had an especially helpful effect, the degree of benefit depending upon the rate of feeding between .06 per cent and 1.0 per cent. Presumably it was again, mainly a matter of vitamin A.

But vitamin A is not the only food factor that arms the animal against ill health. In the light of research, one might name various vitamins, various mineral elements and other substances which exert an influence, directly or indirectly. One disorder may invite another; for example, a rickets-producing diet fed to rats may increase susceptibility to tuberculosis. (*Imperial Bureau of Animal Nutrition. Nutrition in Relation to Reproduction with Special Reference to Sterility in Farm Animals.*)

About positive relationships between nutrition and infectious diseases, the Royal Agricultural Society of England, reporting in *"The Farmer's Guide to Agricultural Research in 1935"* said, "there is a considerable body of evidence for which it is difficult to suggest any alternative explanation. One of the clearest cases is that of the relation of diet to resistance against the establishment and maintenance of infestations with parasitic worms. This connection has been established in the case of sheep, pigs, fowls and dogs, and doubtless applies to other classes of live-stock."

In one British trial, two groups of 20 parasite-free lambs were artificially infested with nematod larvae and while one group was well fed, the other was placed on deficient rations. Upon slaughtering and examining the fourth stomachs, the lambs which had received poor rations were found to have retained many more of the parasites. Work reported by the *Council for Scientific and Industrial Research, Australia,* (1933) adds emphasis to "the importance of proper nutrition in the prevention of serious parasitic invasion."

Notwithstanding all this, more data are necessary before the stockman dares to suppose that he can do much about parasitic problems, simply by good feeding.

The stockman is likely to have some ideas on this broad subject of diet and resistance to disease; he may recall trials in which a litter of fall pigs was divided equally at weaning time, with one lot being fed barley, buttermilk and cod liver oil and the other given just barley and water. In the first lot, the pigs were healthy and made good gains while in the barley-and-water

pen, the feeders became unthrifty and some died; when the bodies of the dead pigs were examined at a veterinary laboratory, the cause of death was said to be *haemorrhagic septicaemia* or swine plague. No doubt it was that particular disease that produced death but it does not seem too much to assume that the primary cause of trouble was nutritional and that swine plague was secondary.

Dr. E. A. Watson of the *Dominion Health of Animals Branch*, speaking to the Western Society of Animal Production in 1937, pointed out, by way of example, that micro-organisms of the pasteurella or haemorrhagic septicaemia group are wide-spread in nature and may be found in healthy pigs and in "clean soil";

Courtesy Ontario Live Stock Branch

A healthy specimen! Champion steer at Stockyard Show, Toronto, 1944. Owned by Don Head Farms.

furthermore, that it is "much more likely to be secondary and not a primary disease factor." Dr. Watson would have it that organisms of such diseases as swine plague, are commonly present leading a harmless existence in healthy animals, until those conditions obtain which would favour their multiplication and thus indirectly promotes the disease. "Their activation and the appearance or recurrence of the diseases in which they play their part, depend upon local conditions and environment, exposure to sudden or severe climatic changes, improper housing, crowding, lack of sanitation, poor feeding and deprivation of

essential food constituents, malnutrition, constitutional weakness, the stress and fatigue of railway transportation and other factors which in various forms and combinations tend to lower health, vitality and normal disease resistance and provoke infectious processes." Of such is shipping fever in cattle and horses and now word comes from the United States that shipping fever losses are higher among cattle coming off rations that have been deficient; the injection of vitamin A concentrate to animals being shipped has proved helpful.

Dr. Watson, in the paper to which reference has been made, recognized, of course, that there are highly specific diseases that cannot be related directly to nutrition and other environmental factors. But he added this, "it is better and cheaper to build for health than to raise weaklings and then try every kind of

Courtesy Ontario Live Stock Branch

Good feeding helps! Champion carlot of steers, R.W.F., 1934. C.P.R. supply farm.

substitute to keep them from falling down . . . Is the average swine husbandman not more concerned with the administration of medicinal pills, condition powders, and disease remedies, the fetishism of a hypodermic syringe and needle and with what he thinks are short cuts to health, than with sound health principles

and their intelligent practice? There are no short cuts to health and there are no synthetic substitutes for health."

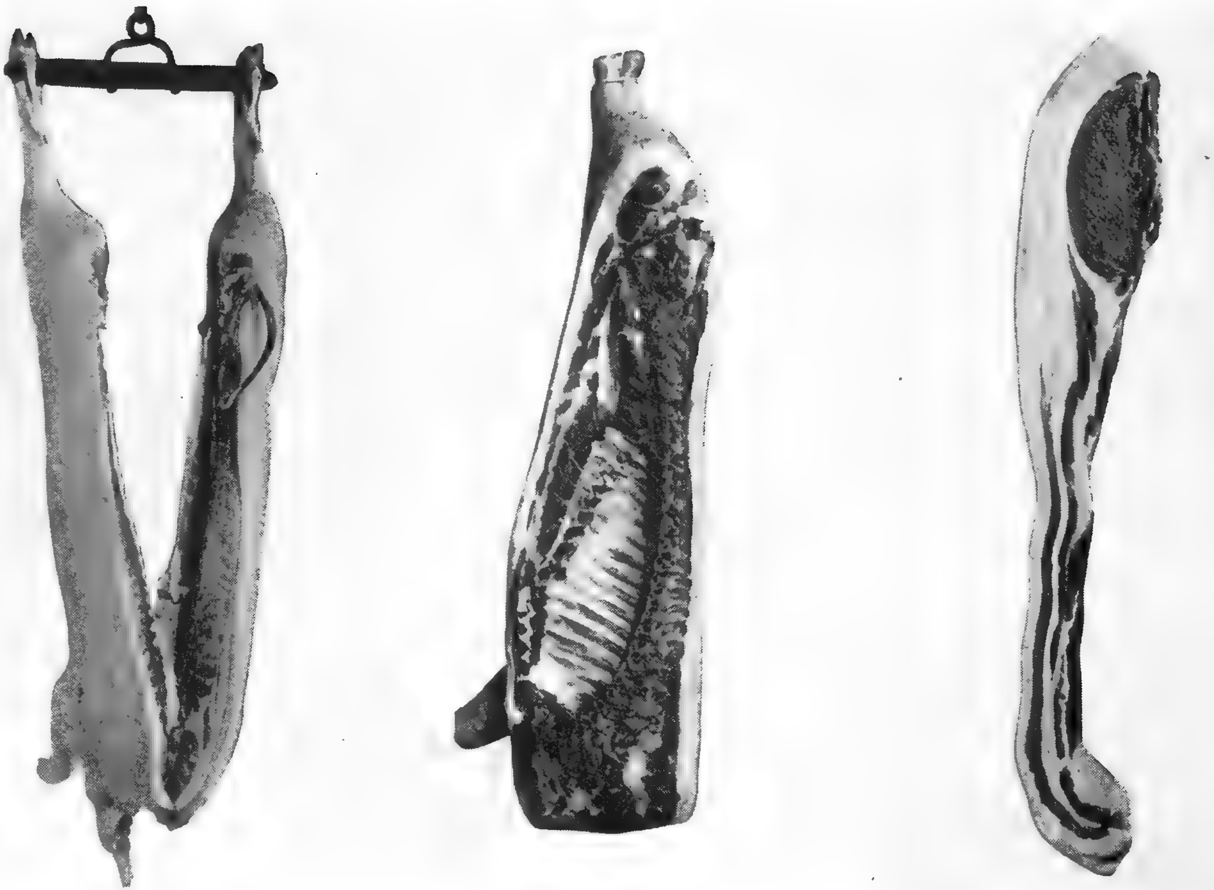
In justice to the subject at hand, an obvious truth will stand retelling;—whatever may be gained through it, better nutrition is not a key to the solution of all health problems in animal production. There are many animal diseases, of which the veterinarian must speak, that do not seem to recognize state of nutrition in any way. Indeed there are certain diseases such as black-leg in cattle and foot-and-mouth disease which are more prevalent among well-conditioned and presumably well-nourished animals.

But the main conclusion is simply this, that through better nutrition, the health and efficiency of farm live-stock can be made better. The money spent on research in nutrition will be wasted if the newer knowledge is not employed where it can do the most good,—on the farms.

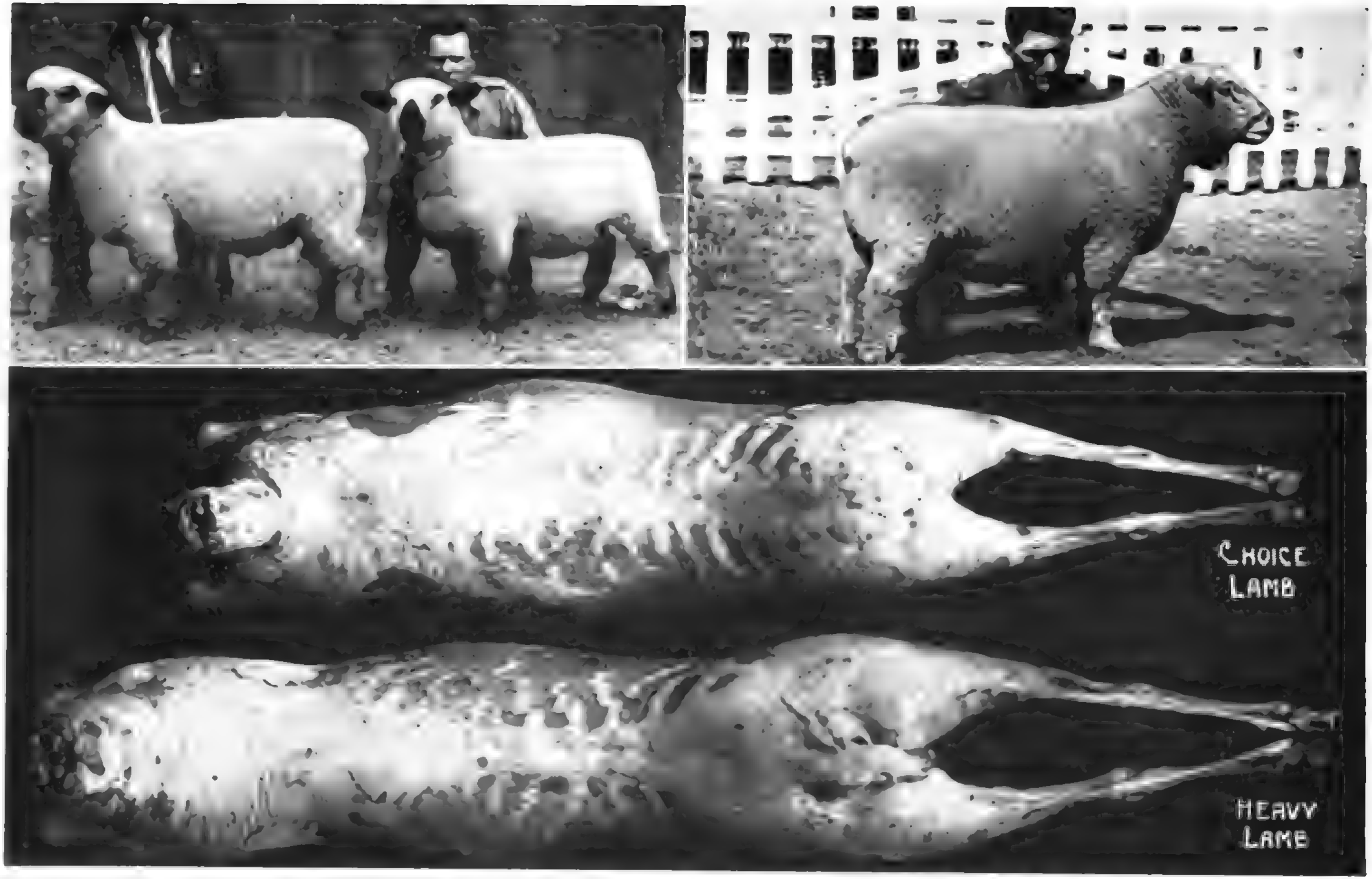



Upper left—Famous Thoroughbred stallion, Brooms, sire of many Canadian winners. Upper right—An American Saddle Horse. Owned in Alberta. Lower left—Ernie Bell on Scotsman, clearing 7′ at Saskatoon, 1935. Lower right—There is a growing interest in saddle horses of both utility and pleasure types.

Upper left—Red Poll cow, Oatland's Coral -11710. Holds breed record in Canada with production of 16,454 pounds of milk and 664 pounds of fat. Bred and owned by A. D. Pocock. Upper right—Aberdeen Angus bull, Bandolier of Glen Ross, a well known champion. Owned by Edwards Brothers, Watford, Ont. Lower left—Lindell Lady's Royal, one of the greatest Jersey show bulls in Canada. Owned by Bellavista Farms. Lower right—Hereford bull, Bocaldo 113th, 159321. Bred by H. A. Onstad, Airdrie, Alberta, and sold at Calgary Bull Sale in March 1945, for $8000.00.

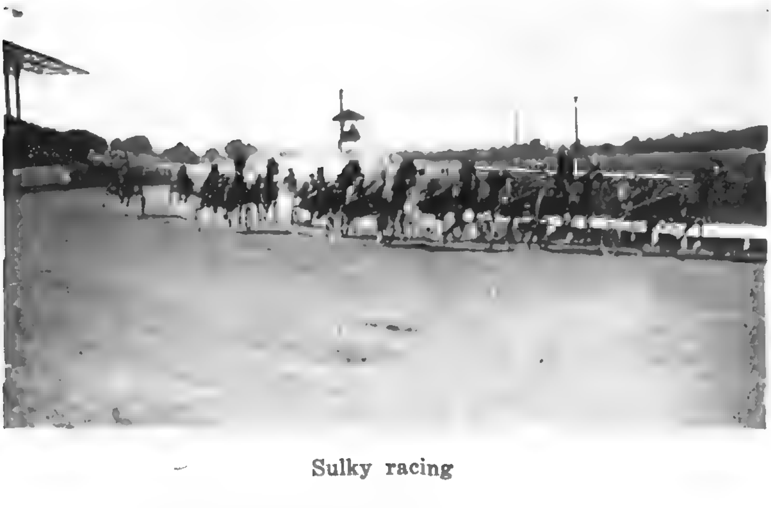


Left—Pig carcass of best quality and well suited for Wiltshire sides. Centre—Wiltshire side, "A-1 sizeable". Right—Cross section of bacon side, showing desirable degree of muscling and streak.



Upper right—Prize winning Hampshire sheep. Property of P. J. Rock and Son. Upper right—Southdown ram, Fowler C. W. 19U. Bottom—Choice and heavy lamb carcasses.

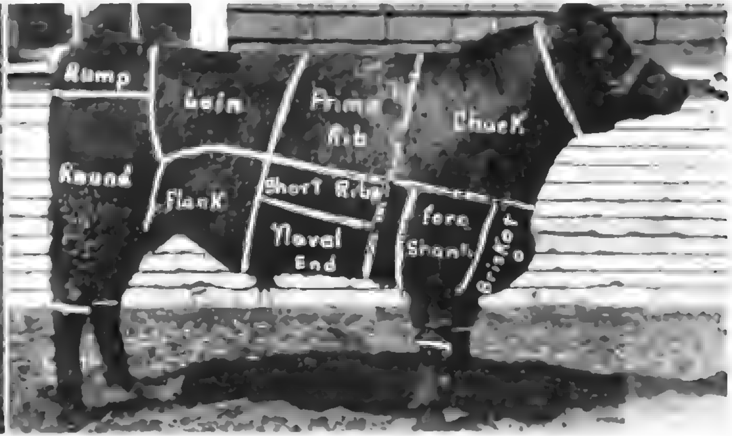
Steer riding competition, Calgary Stampede



Sulky racing

Photo by W. L. Jacobson

Photo by W. L. Jacobson



Upper left—Norseman, Reserve champion Shorthorn bull at Perth, Scotland, in 1943. Purchased by Claude Gallinger of Tofield, Alberta, at 1,000 guineas. Upper right—Lloyd Hanson, 13-year-old cowboy at work at a July Round-up on the range. The horse is a half-bred Thoroughbred. Lower left—A scene from the ranching country of Southwestern Saskatchewan. Buffalo skull reposing amid native cacti and prairie grass. Lower right—Showing location of wholesale cuts of beef.

Belgian stallion, Mon Gros, a Canadian winner.

Percheron stallion, Chief Laet, champion at the Toronto Royal Winter Fair in 1934, and one of the greatest stallions of the breed in Canada. Property of the Dominion Experimental Farms.

PART IV

THE PRINCIPLES UNDERLYING ANIMAL FEEDING

CHAPTER XXIX

THE CONSTITUENTS OF FEEDS

It is not enough to merely keep an animal's stomach and intestine full. If starvation in one of its many forms is to be avoided, the ration must be fitted to the individual's specific needs in point of variety or quality and this demands intelligent direction. It necessitates a careful examination of the composition of the body and the composition of the feeds. In a general way, the chemical constitution of the animal body can be expressed in the same terms as the chemical composition of the feeds. Both can be resolved to the five principles,—water, ash, fat, protein and carbohydrate, although the proportions in plant and animal are quite different.

The comparison holds interest:

	Wheat Grain	*Body of an ox*
Water	11%	56.0%
Ash	1.7%	4.0%
Fat	2.0%	22.0%
Carbohydrate	71.3%	—
Crude Protein	14.0%	17%

Each of those constituents has its own specific parts to play in body welfare and there is a sixth group comprising the vitamins, not so long recognized but none the less essential. Thus there are six constituents or feed groups, to be considered.

Many readers and stockmen are inclined to shrink at such terms as protein, carbohydrate and vitamin. But there should be no apology for their use; indeed it must be clear that the stockman who is a student of his business should be in a position to think clearly about such feed constituents. Perhaps the story can be told in such a manner that those wide-spread feed constituents can carry a practical meaning. After all, those words should be no more forbidding or mysterious than terms like "alternating current", "high tension", "floating power", etc., terms used freely in farming circles.

Carbohydrates, fats and proteins are organic; they can be oxidized or burned and therefore they are the energy formers.

The animal body can burn any one of these to yield heat or energy just as wood, coal or straw can be burned in a furnace. They may be used therefore, to maintain body temperatures at something close to 100°F., 100½°F., in the case of the horse; 101½°F., in the cow; and 102°F., in the pig. In addition, fats can be stored in the body as a concentrated reserve of fuel. But rations must not be computed on the basis of energy alone. The body needs materials notably proteins, mineral substances and vitamins, for construction and special purposes. Lean meat or muscle tissue is predominantly protein, and because there is a constant breaking down of muscle tissue, food protein for repair as well as construction must be provided. In building and repairing muscle tissues, nothing will take the place of protein. Water and ash are non-combustible but have many uses in the body as will be shown.

Feed Analysis

The chemist to whom a sample of feed is submitted for analysis will report composition in terms of the five "proximate principles"; *water, ash, fat, protein* and *carbohydrates*, and he may divide the last into fibre and nitrogen-free extract. In making such an analysis, he will first drive off all water by subjecting a weighed sample of the feed to a temperature of 212°F. or over, until a constant weight is obtained. The loss in weight represents water.

Ash is determined by burning a measured sample of feed and weighing the incombustible residue. Indeed, the ash of plants is not so different in composition from the ash that is taken away from the kitchen stove.

The *fat* is dissolved from the feed by the use of a fat solvent such as *ether* and when the solvent is evaporated off, the fat or "ether extract" is weighed.

Protein, the muscle builder, contains nitrogen in rather constant proportion; about 16% of protein is nitrogen. The crude protein in a feed, therefore, is estimated by determining the amount of nitrogen present and multiplying the result by 6.25. Crude protein differs from true protein in that the former is computed on the basis of total nitrogen, and may include some nitrogen of immature proteins, alkaloids and nitrogenous glucosides.

Carbohydrates are present in two quite distinct forms, starch and sugars which are comparatively easy to digest and which are known as nitrogen-free extract, and secondly the fibre, which is digested with difficulty. The analyst measures the fibre in a

sample after he has dissolved and removed all the other constituents in a dry sample by using weak acids and alkalis ($1\frac{1}{4}\%$ sulphuric acid and $1\frac{1}{4}\%$ sodium hydroxide). Finally, having established the percentages of water, ash, fat, protein and fibre, the remaining part of the carbohydrates is determined by subtracting the total from 100%.

It is appropriate that all who desire to know more about nutrition, pause to examine more carefully, the nature of the respective feed constituents.

"Greenan Golden Glory", winner of the Grand Championship at the Toronto Royal on four occasions

CHAPTER XXX

CARBOHYDRATES AND FATS

Both carbohydrates and fats are made up of the elements,—carbon, hydrogen, and oxygen, although there is one peculiar characteristic to be noted about carbohydrates; they contain exactly twice as many hydrogen atoms as oxygen atoms. For example, lactose or milk sugar has the formula $C_{12}H_{22}O_{11}$. Carbohydrates, comprising a large part of vegetable feeds, are built up within the plant, from carbon dioxide and water, using energy from the sun's rays acting through the green colouring matter in the leaves. That important plant process by which animal foods are manufactured, is called *photosynthesis*. It may be well to note at this stage that all animal food originates in plants. Even the meat eating animals are dependent indirectly upon plants for their food.

Carbohydrates

The carbohydrate group includes the household products, starch and sugar and the less digestible constituent of plants, the fibre. The digestion of all carbohydrates consists of a reduction to a simple form of sugar,—*glucose*,—the only form in which absorption by the intestinal walls can occur. This glucose, known also as *dextrose*, is classified as a monosaccharide and has the chemical formula $C_6H_{12}O_6$. The job of converting double sugars or disaccharides such as *maltose*, *sucrose* and *lactose* to simple sugars is assigned to certain enzymes in the alimentary tract. The convertion involves hydrolysis or in other words, splitting with the addition of a molecule of water. Lactose, upon hydrolysis, yields one molecule of glucose and one of galactose; cane sugar yields one molecule of glucose and one of laevulose, and maltose with the addition of the molecule of water, splits into two molecules of glucose according to the following: $C_{12}H_{22}O_{11} + H_2O \rightarrow 2C_6H_{12}O_6$.

The digestion of starch is more complicated but again, the end product is a simple sugar and the reduction is accomplished by hydrolysis. Recognizing a series of stages involving soluble starch, dextrin and maltose, the convertion of starch to sugar can be summarized as follows: $(C_6H_{10}O_5)_n + {}_nH_2O) \rightarrow {}_nC_6H_{12}O_6$

Hereford cattle enjoying good grazing and shelter

Fibre

The digestive system of herbivorous animals is distinct in its ability to digest considerable amounts of fibre. There are no fibre-digesting enzymes in the alimentary canal and digestion depends upon bacteria and the delayed movement of food material in the tracts of those animals. The rumen or paunch of the cow and sheep and the caecum of the horse are thought to be the principal seats of bacterial attack. In the course of bacterial attack, some of the fibre is converted into methane and lost in the form of intestinal gas, some is broken down to simpler and more soluble forms and some leaves the body unchanged.

Cattle, sheep and horses can digest roughly, 50% of the fibre in their rations. A dog or other meat-eating animal cannot digest fibre, while the pig makes an unsuccessful effort and digests 2% or 3%. This illustrates the mistake that is made when pigs are expected to live on oat hulls which are ground finely and sold under alluring trade names, or even on oats in which the percentage of hull or fibre is comparatively high. In the pig, as in the human, large intakes of fibre may irritate the intestines. There is no better grain feed for young pigs than sifted oat chop, (hulls removed) but feeders have been slow to accept the fact that while ordinary oats which carry 26% or 28% of hull and about 10% of actual fibre, make an excellent horse feed, they are inferior to barley or wheat for pigs. Why? The answer is "fibre".

In connection with digestibility, it should be noted that there is some difference between one kind of fibre and another; one kind may be more fibrous, more woody, more resistant than another. As plants mature, the fibre present becomes impregnated with what is known as *lignin*, with the result that the plant becomes tougher and less digestible, less vulnerable to the attack of the bacterial organisms. The chemist states that such fibre is lignified. In a general way, the high fibre feeds have lower feeding value and the mature fibre is the least usable.

THE CARBOHYDRATES OF PRINCIPLE IMPORTANCE IN NUTRITION

A. Monosaccharides

1. Dextrose (Glucose) $C_6H_{12}O_6$ —Called grape sugar and is the form in which absorption of carbohydrates occurs.
2. Galactose $C_6H_{12}O_6$ —Hydrolysis of lactose produces galactose and glucose.

The Carbohydrates of Principle Importance in Nutrition—Cont'd.

3. Fructose (Laevulose) $C_6H_{12}O_6$—Occurs in ripe fruit.

4. Xylose $C_5H_{10}O_5$ —A pentose sugar occurring in fibrous feeds.

B. Disaccharides

1. Maltose $C_{12}H_{22}O_{11}$ —Malt sugar is a product of starch digestion. Upon hydrolysis, maltose yields two molecules of glucose.
2. Lactose $C_{12}H_{22}O_{11}$ —Upon hydrolysis this milk sugar yields one molecule of glucose and one molecule of galactose.
3. Sucrose $C_{12}H_{22}O_{11}$ —Cane sugar yields one molecule of glucose and one of laevulose upon hydrolysis.

C. Trisaccharides

1. Raffinose $C_{18}H_{32}O_{16}$

D. Polysaccharides

1. Starch $(C_6H_{10}O_5)_n$ —Present in all vegetable feed stuffs.
2. Cellulose $(C_6H_{10}O_5)_n$ —Constituent of fibre.
3. Glycogen $(C_6H_{10}O_5)_n$ —Animal starch found in liver and muscle tissue.
4. Pentosans $(C_5H_8O_4)_n$ —Associated with cellulose and upon hydrolysis yield pentoses.
5. Dextrins —Occur at one stage in starch digestion.
6. Gums —Occur in plants and upon hydrolysis will yield simple sugars.

The Metabolism of Carbohydrates

After absorption into the portal vein, sugar may be used as an immediate source of energy or may be converted into glycogen or animal starch and thus held in temporary storage in the liver and muscles. This is the only form in which carbohydrates are held in storage in the body. The storage of glycogen represents a reserve of readily available material which can be called upon

without interfering with the more permanent reserves such as tissue fat. The supply of glycogen in the liver will be greatest a short time after a meal. This glycogen has the same general formula as starch and cellulose, but it is soluble in water and there is another difference which is of significance in the laboratory; starch treated with iodine gives a blue colour while glycogen and iodine produce reddish brown.

Insulin secreted in a part of the pancreatic gland and about which the world has heard a good deal in recent years, has much to do with the control of sugars and their ultimate use by the muscles. The formation of glycogen from sugar in the liver and muscles is called *glycogenesis*, and seems to be the work of a reversible enzyme, glycogenase which does its work under the influence of insulin. That enzyme is reversible inasmuch as it facilitates *glycogenolysis* or the reconversion of glycogen to simple sugar in which form it can be burned by the body tissues. Finally, *glycolysis*, which refers to the ultimate utilization of these sugars by the body cells, is dependent upon the hormone insulin, secreted by the islets of Langerhans in the pancreas. If the pancreas were removed or if the islets of Langerhans failed to function as in diabetes in humans, the liver and muscles would lose their capacity to store glycogen and the muscle cells lose their power to utilize the blood sugars. The result would be an accumulation of sugars in the blood. Blood sugars in the human may normally range from 0.07% to 0.17%. If the accumulation goes beyond a certain level, as in untreated diabetes, the surplus will be removed by the kidneys and carried away in the urine, a condition called *glycosuria*.

Glycogen retained by the liver is likely to remain there until the sugar in the systemic blood falls below the normal level, about 0.1% in the human. Physical exertion, fright, terror or nervousness can stimulate the reconversion of this carbohydrate material to sugar. It is known that *adrenaline*, the secretion from the suprarenal glands, will increase glycogenolysis and this will probably account for the immediate increase in sugar in the blood of a frightened cat or wild animal brought to bay. Quite a sound natural provision.

Carbohydrate material looms large in the natural diets of herbivorous animals, and in their bodies, it serves several important purposes, among them the following:—

1. It is the principal source of heat for the body and the main source of energy for all production purposes. It does not enter into the construction of the body as proteins and fats do but as a source of calories or energy, carbohydrates are nearly always the cheapest.

2. A surplus of carbohydrates can be converted to body fat and held as a reserve. Common grains like wheat, barley, and corn are rich in carbohydrates, and are often classified as fattening.
3. Carbohydrates are "protein sparers"; carbohydrates and fats are oxidized before the proteins of the body and thus the latter are protected. Under starvation conditions, carbohydrate reserves go first, then fat and finally proteins.
4. Carbohydrates enter into the manufacture of specific products such as milk sugars.

Fats

Both students and breeders are familiar to a certain extent with fats and oils such as animal products like lard, butter, tallow and neat's foot oil, and oils of vegetable origin like linseed oil. These possess certain obvious characteristics; they are not soluble in water but are soluble in benzine, ether or chloroform. Ether is used most commonly in extracting for analytical purposes. Fats and oils are composed of the same chemical elements that go to make up carbohydrates, namely *carbon, hydrogen* and *oxygen* but there is more hydrogen and less oxygen in the fats, a fact which will explain why fats have a higher heat producing power. A unit of fat will produce about 2¼ times as much heat as the same unit of carbohydrates. Indeed nobody knows better than the lady who is struggling to keep her weight down to what it was when she was 22, that fat-rich foods are the greatest threat to her good intentions.

Chemically, fats are *esters*, resulting from the union of glycerol and fatty acids. The bulk of animal fats are esters in which *stearic, palmitic* and *oleic* acids are united with *glycerol.* The fat stearin, prominent in beef and mutton fat, has a high melting point and olein which is abundant in cod liver oil, olive oil etc., is a liquid at ordinary temperatures.

Digestion and Metabolism

The hydrolysis of fats can be accomplished by heating with alkali; the alkali combines with the fatty acid to form soap and glycerol is released. This is saponification. In the process of digestion, mainly in the small intestine, the hydrolysis of fats is the work of the fat splitting enzyme, *steapsin,* assisted by the saponifying effect of the alkalis in bile and pancreatic juice. At one time physiologists supposed that fat in a finely emulsified form could be picked up by the walls of the intestine but that is now known to be incorrect. Rather, the action of the steapsin, with the aid of the bile, is to split the fats to glycerol and fatty

acids; the products absorbed are therefore glycerol, fatty acids and soap and there is probably a resynthesis in the wall of the gut, to form neutral fat.

Uses for Fat in the Body

Food fat taken into the animal body may be burned to yield heat and energy, converted to butterfat in the case of lactation or stored in the body to serve several purposes. Fat stored in the body can be a reserve of fuel material, a protection to the body against injury and a means to conserve body heat during cold weather.

The value of fat on the body as a protection against winter weather is not to be minimized and cattle which go into a Canadian winter with some fat under their hides, not only have an encouraging reserve tucked away, but actually have the benefit of a protective blanket on their backs. Cold-blooded animals have fats of low-melting point, and animals native to northern latitudes have fats more oily in nature than have the animals of warmer climates. Even in the body of the ox, it may be observed that kidney fat has a high melting point and the fat or oil of the shanks exposed to more cold, is lower in melting point.

In carnivorous animals, food fat is the main source of fat stored in the body but in herbivora, the chief source is carbohydrates. All farm grown feeds carry some fat; the man who is rationing barley is feeding a product in which there is 2% of fat and he who feeds corn is feeding something that contains 4½% of fat. Then there are certain seeds which carry a particularly high percentage of oil, soybeans, for example, with 18%, and flaxseed with 36%.

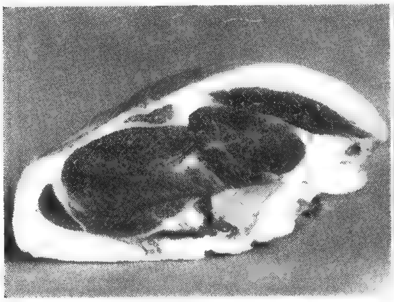
The quality of the food fat will affect the quality of the milk fat or body fat to be produced. Soft pork results from certain oily feeds and is particularly common in the peanut districts of the southern states. Memory recoils to pork carcasses from Tennessee, peanut-fed pigs, seen hanging in a Chicago packing plant. In spite of refrigeration that maintained a temperature of 36°F., the soft pork fat was dripping from the carcasses and spreading out on the floor. Feeding corn can produce soft pork but Canada's soft pork troubles are due more probably to unthriftiness, unbalanced rations, immaturity and underfinish.

For the most part, carbohydrates can be substituted for fat in animal rations. Carbohydrates and proteins consumed in excess of requirements will be converted to fat and a lactating cow consuming a fat-free diet will continue to place the usual level of fat in her milk but it will be fat made from other feed ingredients. Nevertheless, a certain level of fat may be beneficial and work conducted at Cornell Agricultural Experiment

Station has shown that for efficient and economical production of milk, cows should have a grain ration carrying not less than 4% of fat.

Calves and other young animals seem to require some fat and when the dairyman feeds his calves milk from which the fat has been removed, he will usually put forth an effort to make partial restitution by adding a skim milk supplement or butter-fat substitutes in the form of a calf meal mixture rich in fat. Ground flaxseed is a favourite basis for calf meals.

The cat and other members of its meat-eating group can consume feeds of which fats occupy a large proportion and the same is true to a lesser degree with omnivorous animals like the pig. But it has been the experience of animal feeders generally that while oily feeds have advantages under certain circumstances, a high intake of fat is neither economical nor safe.



Sirloin

Rump roast

CHAPTER XXXI

PROTEIN AND ITS METABOLISM

Protein is needed to build and repair muscles and organs in the body and it enters prominently into the constitution of milk, wool and hair. Lean meat is considered one of the best practical examples of protein material and in nutrition, nothing will take the place of protein. In most common feeds, the protein level is low, too low to support rapid growth or certain types of production and one of the first tasks in ration balancing consists of fixing the optimum percentage of protein. It may be that too little protein is the most universal shortcoming of our animal rations. Rapidly growing stock and heavy milking animals have the greatest need and will be the most likely to suffer from limitation.

Protein is distinctive among the feed constituents discussed because it contains nitrogen. The chemical make-up of simple protein is rather complex; *carbon, hydrogen, oxygen* and *nitrogen* are always present, *sulphur,* generally, *phosphorus* occasionally and other elements rarely. *Albumins, histones, globulins, protamines, scleroproteins, gliadins* and *glutelins* are members of the so-called, "simple protein" group. Then there are conjugated proteins and derived or hydrolysed proteins. The conjugated proteins are proteins in combination with something else. For example, *nucleoproteins, phosphoproteins* and *glucoproteins,* and derived proteins are products of protein break-down or digestion. *Metaproteins, proteoses, peptones* and *peptides,* all of which may be found in the intestinal tract, are derived proteins.

Not all the nitrogenous compounds occurring in plants are true proteins. Those immature protein substances which occur as *amides,* more especially in some immature plants and in some field roots, are of less value in nutrition. For the most part, animals are unable to use ammonia, urea and other comparatively simple nitrogenous compounds but it has been shown recently that bacteria working in the paunch of ruminants can convert those comparatively lowly nitrogenous substances into true proteins and thus make them available to the host. Hence, a feed possessing immature proteins may have higher biological value for a cow than for a pig or horse.

Digestion and Metabolism

The digestion of proteins is accomplished by hydrolysing enzymes, through a series of steps, with amino acids the ultimate form in which absorption can take place. But unlike the carbohydrates and fats digested and absorbed, the assimilated protein is not completely burned. In the utilization of the protein material by the body, ammonia, which could be very injurious, is formed. It is one of the jobs assigned to the liver to convert the harmful ammonia to harmless urea and then the kidneys excrete the urea in the urine. The urea represents somewhat of an extravagance however because it is capable of further oxidation. A gram of pure protein burned in a calorimeter will yield 5.8 kilocalories but when the energy value of the urea is deducted, the value of the protein actually used by the animal will be about 4.1 kilocalories or about the same as the caloric value of a gram of carbohydrates.

Amino Acids

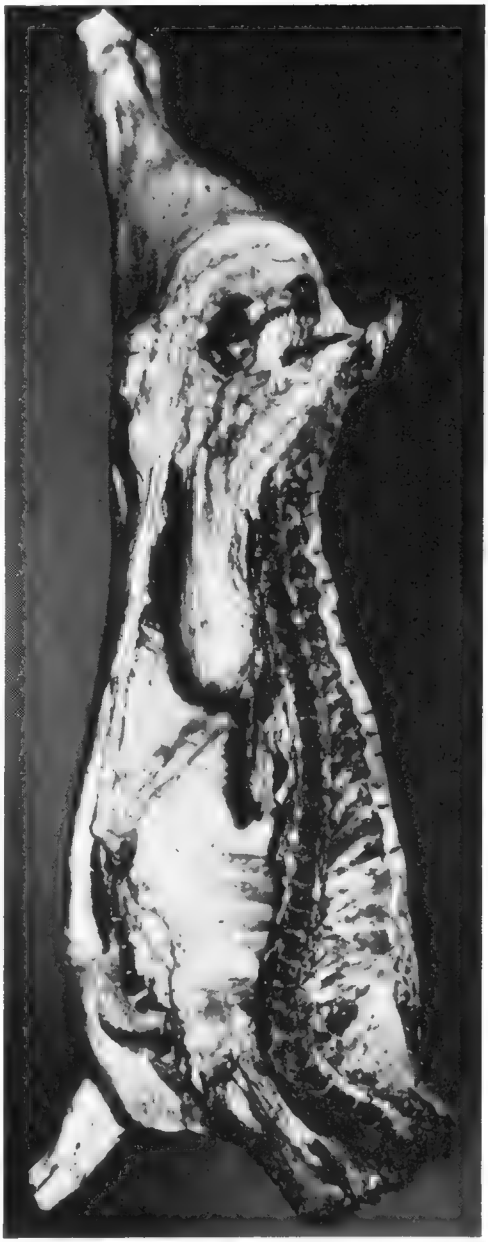
These amino acids of which the mighty protein molecule is composed have been likened to "building stones". There are about 25 different amino acids and most of them are necessary to the formation of a simple protein. For those who may be interested in further study of proteins, some of the best known of the amino acids with their formulae, are set down as follows:

Glycine (glycocoll) $C_2H_5NO_2$
Histidine $C_6H_9N_3O_2$
Cystine $C_6H_{12}N_2S_2O_4$
Leucine $C_6H_{13}NO_2$
Lycine $C_6H_{14}N_2O_2$
Aspartic Acid $C_4H_7NO_4$
Trytophane $C_{11}H_{12}N_2O_2$
Arginine $C_6H_{14}N_4O_2$
Alanine $C_3H_7NO_2$
Tryosine $C_9H_{11}NO_3$
Glutamic Acid $C_5H_9NO_4$

Quality in Protein

Each protein is made up of a certain number of definite amino acids, which may be considered as fitting together jig-saw fashion so that if a unit or piece is absent the formation of the particular protein must be limited. Feed proteins lacking certain essential amino acids which might be needed by the animal are said to be poor in quality, and it is for that reason that variety in such feeds serves to overcome a form of protein deficiency.

Casein, the protein of milk, has high "biological value" because it contains a considerable number of the amino acids required for growth of young animals. The protein of corn, called *zein*, lacks several important amino acids including tryptophane and



A side of good beef

lysine, and *gelatin* has similar deficiencies on account of a shortage of cystine and tryptophane. For use with cereal grains, soybean oil meal has higher balancing value than corn gluten or linseed oil meal. This was a matter of special importance to pig feeders when supplies of protein supplement were inadequate to meet war-time demands in 1942,-43-44.

Proteins of animal origin, milk proteins, meat proteins and egg proteins contain a wide range of protein "building stones" and have, therefore, particularly good nutritional value. Hence, vegetarian feeders require more protein in their diet to ensure the provision of minimum requirements. Omnivora like pigs and humans are likely to obtain better nutrition from proteins of animal origin. In pig feeding, for example, it has been shown that ration balancing with supplements such as skim milk or tankage is more effective than when a product like linseed oil meal is used. Some protein of animal origin is most essential in a pig's ration but it does not follow that all or even most of supplemental

proteins must be of animal origin. Commercial supplements or concentrates representing a mixture of vegetable and animal proteins have given good satisfaction and it is generally agreed that when between 35% and 40% of a mixed concentrate is made up from tankage, fish meal and other such products of animal origin, satisfactory results may be expected.

Urea and the Immature Proteins

Between the relatively simple nitrates absorbed by plants and the complex mature proteins so valuable to farm animals, there is a range of intermediate products which, for purposes of convenience, may be given the group name *amides*. Some feeds like turnips, potatoes and young grass, contain considerable quantities of these immature proteins. Amino acids, the so-called "building stones" and urea which is a by-product from protein utilization in the animal body, are among the intermediate products. No practical means has been found to effect the synthesis of mature proteins but certain of the amides can be manufactured in industry and the question arises as to the extent to which such nitrogenous products of industry can be used in live-stock feeding.

It is now clear that cattle and sheep can use a certain amount of urea to meet their protein needs. Here is the secret: bacteria in the rumen are able to use amide materials such as urea, and build them into mature proteins in their own microscopic bodies. Then, in time, the cow or sheep is able to digest and use the bacterial protein and thus the matter of quality of proteins ceases to be so important. Horses may also harbour bacteria with similar ability somewhere along the intestinal tract.

Urea which is useful for many purposes,—fertilizer, explosives, plastics, etc., may some day replace a part of the linseed oil meal in dairy cow rations. German scientists before the first Great War, demonstrated that up to 40% or 50% of the protein material allotted to ruminants might be replaced by such simple amide substances as urea and ammonium bicarbonate. No ill effects have been reported and no deterioration in yield or quality of milk, when experimental feeding has been conducted. In using commercial urea, it will be up to the feeder to combine it with feeds which will overcome the unpalatability of that product.

Optimum Protein Levels. A surplus of protein taken into the body can be burned to form energy or converted to fat, but protein is a comparatively costly form of "fuel" and to exceed optimum requirements usually represents extravagance. But rations containing too little of these muscle building materials are by far the most common and they too must represent extravagance through reduced efficiency in production.

For reasons which will be readily understood, working horses, fattening cattle, fattening sheep and non-lactating mature animals, do not require a lot of protein. But it is different with growing stock and milking females. Insufficient protein results in limited growth in young animals. Milking cows on rations containing insufficient protein will decline in production; but up to a certain point they will draw protein from their own bodies, and thus sustain the flow of milk at a level higher than that which could be supported by the feed alone. Cow's milk contains around 3.5% protein and it should be remembered that no other feed nutrient will take the place of protein in reconstructing protein in milk or meat.

Skim milk, buttermilk, tankage, meat meal and fish meal are the principal protein supplements of animal origin and are used extensively in pig feeding. The vegetable proteins, as mentioned, are less efficient and linseed oil meal and alfalfa meal by themselves are not satisfactory for pigs; but consistent with the observation that mixed proteins have enhanced value, a mixture of tankage, fish meal, linseed oil meal and alfalfa meal will give better results than any one of those products used alone.

Linseed oil meal, soy-bean oil meal, cotton-seed oil meal and gluten meal or feed, are among the best protein concentrates for cows, while bran, with a lower percentage of protein is also good. But for cattle, sheep and horses, the legume hays, alfalfa and the clovers, have much of a practical nature to offer. They are rich in bone-building elements as well as in protein and offer a means by which the farmer can grow more to meet his feed requirements while enriching his land at the same time. When legume hays constitute between 40% and 50% of the roughage fed to milking cows in average production, the need for commercial supplements is reduced practically to nil.

It is a recent view that protein deficiency in point of either quantity or quality may influence sexual behaviour and breeding efficiency. It is not impossible that certain forms of breeding difficulties encountered by Canadian stockmen are caused or aggravated by low intake of protein. Russian studies have shown a marked improvement in the numbers and quality of sperms in the case of bulls, boars, rams and stallions, when protein was rationed generously.

CHAPTER XXXII

WATER

Water is food and like other constituents of the diet it must pass through the stomach and be absorbed by the wall of the intestine before it can be put to use within the body proper. There is a dendency to regard water with such familiarity that the provision of all the clean water farm animals need and want, is sometimes taken too lightly. Reduced efficiency is the inevitable result.

Insufficient water will produce a form of starvation just as a lack of any other ingredient of the food. Indeed, an active animal will die more quickly if denied water than if denied feed of other kind. It is true that some species in the animal world survive long periods with no apparent consumption of water, for example the gopher which infests the prairie wheat field, the ordinary clothes moth that spends its ugly life in woollen clothes and the hibernating animal such as the brown bear, groundhog, ground squirrel and skunk. How do those animals get along without water? Actually, they are not without water but their requirements are reduced. The wheat-field gopher eats green plants that are high in water content and the clothes moth, by excreting uric acid rather than urea, makes the small amount of water in its food suffice.

The Hibernating Animal

The case of the hibernating animal is of special interest. Drought in late summer will induce an earlier hibernation in ground squirrels and gophers and other animals that depend largely upon green forage for their water intake. It seems that animals will fast for a few days or a week before hibernating and consequently the alimentary tract is emptied. Then, in the nest that it has prepared, the creature will curl up in a ball and mouth and eyes will be closed tightly when the long sleep begins. Such will reduce loss of moisture. The hibernating animal goes into winter quarters with a substantial reserve of fat packed away under its hide; the respiration rate slows down; the heart action decreases and fat is burned to maintain temperatures and

physiological processes at a reduced rate, and there is very little oxidation of proteins. When proteins are not being burned, there is no urea to be carried away as waste and secondly, in the oxidation of fat and carbohydrate, there is a certain quantity of water released; it is called metabolic water and is sufficient to meet the reduced requirements of the animal which is spending its winter in sleep. Sugar when used in the body yields 60% of its weight as water and fat, 100%.

The ground squirrel will emerge from its winter quarters, weighing about half of what it weighed when its sleep began.

Water in the Animal Body

Water has many uses in the body; it assists in the movement of digested materials and glandular secretions; it conducts waste and harmful materials from the body, in urine and sweat (sweating and the evaporation of water from the skin help to cool the body) ; and finally, water enters into the makeup of the body in a large way. The water content of the foetus at an early stage of development is close to 90%, and a new-born calf has in its body about 70% or 73% of water. With advancing maturity and increasing fatness, the water content of the body is reduced in such a manner that the two-year-old feeder steer contains about 55% water, while a fat steer of the same age might have about 50%. Herein is the main reason for young cattle of the baby-beef order making more economical gains than older cattle. When a feeder calf makes a pound of gain, it inevitably incorporates 5% or 10% more water in the increased weight than does a two-year-old feeder.

Water content varies greatly in feed. Threshed grains and hay in storage have between 10% and 14% of moisture, but when moisture exceeds the latter figure, there is grave danger of spoiling. Corn silage has about 75% of water and roots have from 85% to 90%.

Someone is sure to contend that there is a big difference in water. A civil servant giving a public discourse on the subject of feeds in old Aberdeenshire was pointing out that turnips or "neeps" were about 90% water, and in the light of that fact, their value was often overstated. An old Scot who had more confidence in his experiences in the byre than in "book-learning", volunteered that "neeps may be 90% water, but it's uncommon good water". The fact is that pure water is the same wherever one finds it, whether it is removed from a turnip or caught in its descent from the heavens. But water as the farm animals consume it naturally varies considerably on account of mineral salts and impurities present.

Alkali Water

Well water in many parts of this land is "hard" or "alkali", which simply means that it contains salts in solution. With respect to total solids and the nature of the chemical ingredients present, there is wide variation. Unless the nature of the salts is known, the total salt content is not a good criterion of water's unsuitability for drinking but in a general way, it may be assumed that water having a salt concentration exceeding 1.4% is not suitable for stock watering purposes. Where the salts in well water are predominantly sodium sulphate (Glauber's salts) or magnesium sulphate, (Epsom salts), a maximum concentration for safe use might be fixed at around 0.6% or 0.8%. In many Mid Western wells, the salts just named, along with calcium sulphate, common salt and sodium carbonate are most common. The presence of a little common salt in the well water may be beneficial and the calcium salts might likewise be beneficial but where large amounts of sodium and magnesium salts are taken into the system, definite injury can result. It is now suspected that drinking water which is strongly alkaline may be a factor in causing breeding troubles in farm animals. Breeding performance in rats was definitely reduced by such water.

Amounts of Water Needed by Live Stock

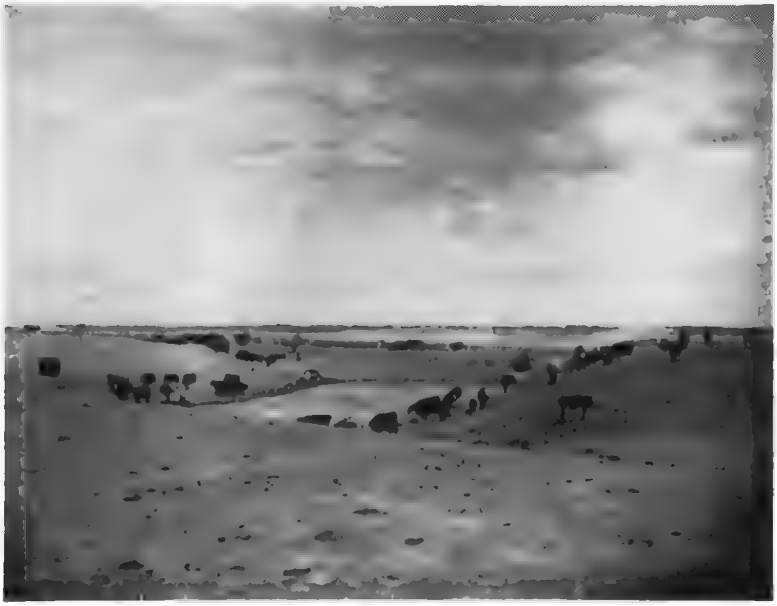
"Pure water and lots of it" should be the slogan with livestock growers. The actual amount that an animal will need is likely to depend on various factors,—surrounding temperatures, form of production, moisture in the feed and physical work being performed. High protein rations necessitate larger consumption of water and dry feeds call for frequent waterings. Cattle or sheep eating finely ground feed will take more water and want it frequently. Cattle and horses wintering on straw are more likely to suffer impaction and other digestive troubles if water is not available as required. One important reason for the use of the tank heater in removing the chill from the drinking water during winter months is to ensure greater and more normal consumption of water thus contributing to normal digestion and elimination.

Milking cows have a particularly high water requirement, partly because 87% of milk is water. Dry cows kept under average winter conditions will take about 75 pounds daily; cows in high milk production will consume from three to five pounds of water per pound of milk produced daily. That represents a per day consumption of roughly 160 pounds of water for the cow giving 40 pounds of milk. It has been shown conclusively that dairy cows having constant access to water will consume

more of it and give more milk than those animals which are watered only once or twice daily.

Horses will require from 60 to 100 pounds of water daily and more if working steadily in warm weather. Sheep will take a gallon or more of water a day, and pigs are frequently fed a slop which is based upon one part of grain and three parts of liquid by weight.

It may not be good policy to allow horses which are extremely hot to drink their fill of cold water, but as a general rule it is well to recognize the animals' appetite for water as a dependable indication of need.



P.F.R.A. dam in a community pasture at Bracken, Sask. Overgrazing can easily occur around the "water-hole".

CHAPTER XXXIII

MINERALS IN NUTRITION

There has been a lot of loose talk about mineral supplements and many extravagant claims for the merits of certain commercial mixtures. The impression has been given too often that a certain brand will compensate for all deficiencies in rations. Such is false. Mineral deficiencies are a source of loss in livestock production and there is a definite place for supplements in present day rationing, but mineral material in the ration will not furnish energy; it will not supply or take the place of protein and it will not relieve a vitamin deficiency. Nevertheless mineral matter in the ration has important functions to perform and a better understanding of mineral nutrition could be profitable.

About 4% of the animal body is incombustible; that much in ash. The same is true of the human body. The body of a certain noted revolutionary who died in exile in 1940, was cremated and the newspaper reported that all that remained was ash totalling six pounds or about 4%. But the ash from plants and animals is much more complicated than might appear on the surface and fully 18 or 20 different chemical elements are present in the mineral part of an animal and all must have come at one time or another from the feed. Some of those elements seem to have no special purpose in the body and their presence may be accidental; certain others are furnished in abundance in the most meagre rations; fortunately there are only four or five mineral elements that the stockman need worry about.

For those who wish to pursue the study of the mineral elements in the body further, the following classification is offered:

Sodium Chlorine Calcium or lime Phosphorus Iron Iodine	Elements most likely to be deficient	Essential elements which must be furnished in the feed
Cobalt Magnesium Sulphur Manganese Potassium Copper Zinc	Elements not likely to be deficient	

Fluorine Boron Bromine Aluminum Nickel Arsenic Cadmium Silicon	Trace elements present in the body but to which no special or useful purpose has been assigned

What are the functions of these various mineral substances in the body? The functions are legion. In addition to providing structual stability as in the bones and teeth, these substances control many body processes; they help to maintain a proper balance between the acids and alkalis; they have a part in directing osmotic movements; they have a part in blood clotting and heart activity and they enter directly into the composition of certain body tissues and fluids. Eighty-five per cent of the mineral matter of the body is in the skeleton while the balance is present in the soft tissues and body fluids. And let it be noted that an animal will die sooner on an ash-free ration than it will if no food whatever is consumed.

In the case of mature animals on a maintenance basis, feed minerals are needed in comparatively small amounts to meet the losses due to wear and tear, but growing animals and those in heavy milk or other form of production have correspondingly greater needs.

Why the apparently increased need for additions of mineral material in modern rations? Two reasons can be offered,—first, the demand for faster growth and greater production in farm animals, and second, a tendency to soil depletion coupled with climatic variations. In connection with the former, it need only be noted that a 1,200 pound cow producing 10,000 pounds of milk a year, actually secretes in a year twice as much dry matter and about 1½ times as much mineral matter as there is in her body. And in connection with climatic variations, it may be observed by way of example, that a lower content of phosphorus characterizes the grass and other forage in years of drought.

A close connection exists between nutritional deficiencies and disorders in the animal body. Mineral deficiencies manifest themselves in various ways; rickets and tetany are related to a failure in the metabolism of calcium and phosphorus; anaemia in suckling pigs is due to a shortage of iron; hairless litters and goitres in new-born of all species reflect an iodine shortage, and unthriftiness and poor use of feed may indicate too little common salt or other necessary product. Undoubtedly there are many borderline deficiencies which are sufficiently serious to cause inefficient production but not bad enough to produce readily recognized symptoms of the common nutritional disorders.

Common Salt

Insufficient common salt (sodium chloride) will reduce physiological efficiency, depress appetite and impair feeding qualities. Heat and sweating increase the demand for salt because of huge losses in perspiration. But an animal's salt requirement is in keeping with the nature of the diet. High intake of roughage calls for more salt; lush spring grass is high in potassium, and with a high potassium diet there is high excretion of sodium along with potassium in the urine. The wild animals of the meat eating group take no salt except the little that is present in the blood of their prey, while the vegetable feeders like the horse, cow and sheep, have a large requirement and one which cannot be neglected without substantial reduction in efficiency. The pig, like the human, is a mixed feeder, and in point of salt consumption should be and is about intermediate.

Those who have overlooked the pig's requirement in this respect have made extravagant recommendations about salt allowances, advising an allowance of 2% and 2½% in the grain. On the other hand, there are folk who have an idea that salt is toxic to pigs, because somebody "back home" dumped the salt brine from a pork cure into the pig trough and the pig drank the brine and died; the saltpetre in the brine or certain products arising from putrefactive breakdown of proteins would be more likely to have caused the trouble than the salt. The pig should have salt, but how much? Perhaps the pig itself is the best judge of its need for salt; most humans reserve the right to apportion salt to themselves. In self-feeder trials with pigs at the University of Saskatchewan, the intake of salt never exceeded one-half of one per cent or one-half pound of salt to 100 pounds of grain consumed; and in other trials, the one-half of one per cent level of salt produced just as good returns as any higher rates tried. It is an important fact however, that all classes of farm animals should get the amount of common salt for which they show an appetite.

In some parts of the prairie provinces, feeders have made the mistake of depending upon a crystalline product taken from lakes and sloughs, to replace common salt in rations. Those products, frequently taken from prairie lakes, represent the crystallized form of certain alkalis present in the water; in some cases the mixture is sodium sulphate (Glauber's salts) and magnesium sulphate (epsom salts) and in other cases it is almost entirely Glauber's salts. Only rarely is there an appreciable amount of common salt or sodium chloride. Glauber's salts and Epsom salts, as stockmen know, have medicinal properties and are occasionally administered as cathartics, but nutritionally they have no place in practical live-stock rations in this country. Fed

when not required, they may be injurious. It has been shown for example, that a continuous intake of Glauber's or Epsom salts can have the effect of interfering with the absorption of calcium and phosphorus; they may thus be a handicap in nutrition, rather than an aid. Indeed, the continued use of those products containing high percentages of Glauber's and Epsom salts must have about the same detrimental effect that the use of certain strongly "alkali" waters would have. Consequently, farmers are urged not to buy salts of undetermined constitution for use as a substitute for common salt.

Calcium and Phosphorus

Calcium and phosphorus are the bone builders and together they account for nearly 90% of the ash in the body. The natural bone of mature animals consists roughly of 50% water, 25% ash, 20% protein and 5% fat. Teeth have a higher percentage of mineral ash and less water.

Rickets

An inadequacy of dietary calcium or phosphorus or failure of absorption will result in depraved appetites, unthriftiness, inefficient production and perhaps stiffness and rickets. Rickets may be described as a failure in the deposition of calcium or phosphorus in the bone tissue and it may be caused by insufficient materials, an improper ratio between calcium and phosphorus or insufficient vitamin D to allow the use of the bone building materials eaten by the animal. In providing for the health of the bones, therefore, it seems to be more a matter of calcium and phosphorus in the blood than in the food because an animal might be eating these materials in abundance and still be suffering from bone starvation. When the calcium and phosphorus in the blood drop to a certain low level, these elements are no longer laid down in the bones. We hear much about calcium-phosphorus ratios. The two elements occur in bone in the proportion of 2 to 1 and this seems to be about the correct ratio in feeding. When vitamin D is present in sufficient abundance, the ratio is of less importance and satisfactory nutrition can be obtained outside of the 2:1 ratio.

In any case, the result of inadequacy is a lowered ash content of the bones with corresponding weakness; the manifestations which have been all too common during the winter months are unthriftiness, swollen joints, bowed legs, lameness and pain. Fractures occur more easily. Osteomalacia is a similar disorder sometimes called the "rickets of adults"; it was prevalent among humans in parts of Europe during the first Great War when people were obliged to live on restricted diets.

Assimilation

It becomes apparent, then, that the feeder must consider something more than the provision of calcium and phosphorus in the ration. Assimilation into the system is actually more vital than intake at the mouth and the intestinal walls are evidently a bit temperamental. Without vitamin D there is no assimilation and if the insoluble compound, tricalcium phosphate, is formed, there will be no absorption. Consumption of milk has been observed to promote absorption in humans (and probably the same is true in pigs) because the milk sugar called lactose creates that acid medium in the intestine, which seems to prevent the formation of the tricalcium form and thus it favours calcium and phosphorus absorption. Nature's way is usually reliable and it is to be noted that the natural food of the infant animal supplies not only the calcium and phosphorus that are necessary to bone construction but also the milk sugar which helps to ensure that these elements be retained for the body's use.

Excessive amounts of fat will interfere with calcium absorption, and too much iron or magnesium will retard the absorption of phosphorus. In the case of the latter, insoluble phosphates are formed. Too much lime in a ration has been found to retard hemoglobin formation in rats, apparently due to interference with iron assimilation; a calcium-phosphorus ratio in which the phosphorus is comparatively high has been optimal for iron absorption.

The interaction of one food ingredient with another has seemed to rob the study of nutrition of its last vestige of simplicity. It may be that taking mineral oil regularly for the purpose of relieving constipation is interfering indirectly with calcium and phosphorus absorption. How? Vitamin D which is essential to calcium and phosphorus absorption, is, like vitamin A, fat soluble and when such a vitamin comes into association with an oil that is not digested or absorbed, it is likely to be carried through the intestinal tract, beyond the reach of the animal. Live-stock men have sometimes fed mineral oil and perhaps with detriment.

Canadian stockmen will be able to relate calcium or phosphorus deficiency with a number of disorders that have resulted in loss. Rickets is a disorder which has occured widely. Tetany, which has been a source of loss in growing pigs and characterized by convulsions and muscular spasms, has been traced to a shortage of blood calcium. A farmer reports that his weanling pigs seemed to be doing well but when he went to feed them and they began to run to the trough, one or more fell over in a convulsion and appeared to be dying. But the feeding of lime water to these shoats overcame the trouble and prevented recurrence.

Then there has been a paralysis occurring in pregnant and nursing sows, more particularly nursing sows upon whom there was a heavy burden due to milk production. In some instances, bone depletion had advanced to the point where a fracture of some bone in the hind part of the body occurred easily. Some such cases might have been prevented if the sow's ration had been properly fortified for purposes of bone restoration.

Indeed it may be a wise precaution to feed a little ground limestone, say one-half of one per cent, in the grain, to both pregnant and milking sows. In each of six consecutive winters, the University of Saskatchewan sows were divided so that half of the number received a limestone supplement. In the number of pigs farrowed and in birth weight there was no appreciable difference between the two lots of pigs but with regard to weaning weight, the pigs from the lime-fed sows were consistently ahead of the others by nearly 25 pounds per litter. More than that, there was no case of failure in coming to milk, among the sows receiving the supplement.

Lime and Lactation

There does seem to be a significant relationship between the provision of the necessary calcium and milk supply. This is not

Courtesy Ontario Live Stock Branch

First prize graded Holstein herd. R.W.F., 1934. Owned by M. L. McCarthy.

surprising because milk which contains 0.7% of ash, has 0.12% of calcium and 0.09% of phosphorus. A strong connection between blood calcium and milk fever is now recognized and the modern treatment consists of injecting a solution of calcium salts, usually calcium gluconate. The old treatment involved the pumping of air into the udder so that milk secretion would be stopped and the further withdrawal of lime from the blood, halted.

One gallon of milk contains more calcium than there is in the entire blood of a cow. When milk fever sets in, blood calcium may be found to drop from the normal level of 10 milligrams per 100 cubic centimeters of blood to half that amount. To what extent milk fever could be prevented by correct feeding, we cannot be sure but there is a strong possibility that losses could be reduced. This is the view expressed by Dr. E. M. Gildow of the Carnation Milk Farm (*Carnation News, Winter 1940*). That the parathyroid gland has a lot to do with the regulation of the level of calcium in the blood is generally known and Dr. Gildow suggests that there may be a hereditary factor involved, which would explain why milk fever is more common in some families than in others. After stating that there are very few cases of milk fever at Carnation, he offers this: "The three steps involved in the prevention of milk fever then are,—the breeding of cows that are resistant to the disease; the supply of adequate amounts of calcium, phosphorus, and vitamin D; and the application of practices that will reduce the initial milk flow of cows at calving time."

It was shown by Forbes of Ohio, that cows in heavy production cannot maintain the mineral reserves of their bodies. In other words, the glands of the udder, in such cases, withdraw calcium and phosphorus from the system faster than the intestines can take these elements from the food. Recent American work shows that the net loss of calcium from the cow's body may amount to 20% of her total, toward the end of lactation. This only emphasizes the importance of good rationing and the intelligent provision of materials rich in calcium and phosphorus during the drying-off or dry periods, preceding the next calving. There may be only a short period when the reserves can be put in order and when such is not done, the result may be a reduced level of production or what the dairyman has described as a "burnt out" cow.

Actually, however, cattle and sheep are more likely to require supplemental phosphorus than calcium. The bone chewing habit among cattle and the accompanying loss of appetite are the result of inadequate phosphorus. That condition has been common in farming and ranching districts alike, especially through the dry

years. Placing edible bone meal or some other reliable carrier like mono-calcium phosphate where the cattle can get it easily, will prevent or correct such behaviour and increase the animal's producing power. Sometimes one of these carriers of phosphorus is mixed with salt and placed in troughs or hoppers on the range.

Pigs are likely to require supplemental calcium more than phosphorus while cattle and sheep are likely to demand supplemental phosphorus more than calcium. The reason is not hard to find; the growing plant holds the secret. As the plant matures, most of the calcium is retained in the stem and leaves while most of the phosphorus is deposited in the seeds. Consistent with standard practices, cattle, sheep and horses eat the forage part of the plant while pigs eat the seeds. Accordingly the pig is likely to be short on calcium for balancing purposes and the strictly herbivorous animals, if they are not eating a fair amount of grain, are most likely to need phosphorus.

The pig can get a good measure of the calcium it needs from skim milk, buttermilk or tankage but if these are not available in sufficient quantities there is no more appropriate calcium supplement than a good grade of ground limestone. The high magnesium limestone or dolomite is not a good kind for pigs. Ground limestone has given good results in many trials with pigs, while bone meal and other carriers of both calcium and phosphorus have failed to produce a worth-while response. Nevertheless, carriers of both calcium and phosphorus such as bone meal, have a good deal to offer in preventing bone chewing in cattle, pregnancy disease in ewes and perhaps other disorders in herbivorous animals that have been handicapped by domestication.

It should be noted here that milk as a feed not only supplies calcium and phosphorus in substantial amounts, but the lactose in milk creates the best medium for the absorption of those elements.

Every student of animal nutrition should know that the milks and legume hays are especially rich in lime and wheat bran, linseed oil meal and skim milk are among the best of the common feeds in phosphorus content.

Iron. Iron is the next in that little group of mineral elements about which the Canadian stockman should know something. In the body of the adult there is only about 0.004 per cent of iron by weight but it has a great deal to do in the movement of oxygen from the lungs to all parts of the body. Fortunately, iron deficiency is common in a single group of farm animals only,—nursing pigs; and then only where the young pigs are

being reared on board or cement floors. Anemia is the disorder that affects such young pigs and anemia is a blood deficiency. Iron is an important constituent of red blood cells; iron gives the red blood cells their ability to carry oxygen from the lungs to the tissues. Countless millions of these cells are employed for the job of carrying oxygen, or making "draught" for the burning process in the body. In the human family, the healthy male has 5,000,000 red blood cells per cubic millimeter of blood and the female has 4,500,000.

Any substantial reduction from the normal number of red blood cells will mean anemia. But fortunately, the body is most economical in its use of iron and most classes of animals get all they require from common rations. The suckling pigs reared on piggery floors are the exception as far as farm animals are concerned. The pig at birth has a store of iron in its liver, sufficient to last two or three weeks or until the young animal is able to root in the earth and there get the wanted mineral. Sow's milk is deficient in iron and feeding iron compounds to the sow will not correct the deficiency. Evidently the same is true of the rat because anemia of a pronounced order can be produced in young rats in two weeks if no other feed than milk is permitted.

When man restricted those young pigs to floored pens, he discovered that in attempting to improve upon nature's way, he was making new trouble for himself and his pigs; if the pigs couldn't go to the soil, the soil would have to be brought to the pigs and the practice of placing a shovelful of clean earth before each litter became a part of good management during winter and early spring months. It is between two weeks of age and weaning time that the problem is greatest and if attention is not given, the young animals will be going "off colour" at three weeks of age; they will be pale and lazy and may develop diarrhoea and thumps. And at four to five weeks of age there will be deaths. Because the shovelful of dirt placed in the pen daily is a comparatively poor substitute for the open range, it has been found helpful to step up the iron content of that soil by sprinkling it with a solution containing iron; a solution of ferrous sulphate (iron sulphate or copperas) is recommended. As an alternative, a solution made by dissolving 6 or 8 ounces of the ferrous sulphate in a quart of warm water, can be painted on the sow's udder once a day while the young pigs are between one and seven weeks of age.

Iodine. There is only a trace of iodine in the body but the part it plays is extremely important. It has long been recognized that certain areas were goitre-producing, but the nutritional significance of iodine was not understood until comparatively recent

times. When Captain John Palliser made his classical survey of what is now Western Canada, between 1857 and 1859, members of his party recorded that goitre was very prevalent among the residents at Fort Edmonton and Rocky Mountain House and among the Sarcee Indians. There is an amusing explanatory footnote to the effect that in the case of these Indians, the goitre is "probably the result of intermarriage with relations."

Iodine is vital to the normal functioning of the *thyroid gland* which is situated alongside of the wind-pipe, close to the larynx. The thyroid is classified as a ductless gland and its secretion, called thyroxine, is about 60% iodine. Most of the iodine in the body is in that gland.

Thyroxine is a powerful force in the body. One of its functions is to control metabolism, i.e. maintain a balance between the building up and breaking down forces. A superabundance of thyroxine would have the effect of accelerating the burning processes and the individual would become emaciated while an abnormally small amount of thyroxine would result in marked increase in body stores and weight. A shortage of iodine is likely to manifest itself as an enlarged thyroid or simple goitre; enlargement in this case represents an attempt to compensate for a deficiency. There may be other contributing causes in the case of goitre; a disturbed balance of vitamins A and C, a large intake of calcium when iodine is low and excessively high consumption of fat are factors which seem to aggravate an iodine deficiency, perhaps through reduced absorption through the intestine. Then too there is suggestion of specific goitre-producing agents which may be present in certain foods, including cabbage.

There are other types of goitre in humans and a thyroid insufficiency in early childhood can cause cretinism, with interference of both physical and mental development.

In farm animals, the great loss in new-borns, hairless pigs at birth, and goitred lambs and calves, have simply reflected an iodine deficiency. Hairless calves and wool-less sheep have been reported but are most uncommon.

The oceans carry great stores of iodine but in regions far inland, the soil, water and vegetation are often too short of iodine to meet the requirements of our animals, especially the pregnant females. It has been supposed that certain soil areas might be marked as iodine adequate. A survey of the province of Saskatchewan was conducted by the Department of Animal Husbandry, University of Saskatchewan, and pig and sheep breeders in all sections were asked to report their experiences. The only conclusion that could be reached was that the entire province is more or less iodine deficient and that in no part should the stockman attempt to raise pigs, lambs and foals without the provision

of some iodine for the pregnant females. Certain districts appeared to be more seriously deficient than others; an area north of Abernethy, one south of Tisdale and the grey soils north of the Saskatchewan River had particularly bad records.

O. J. Walker reported a study of the iodine content of Alberta waters, mostly well waters. Reporting on 118 samples, the iodine content varied from 0.1 part per billion of water to 660 parts per billion. Surface water from streams and shallow wells was particularly low, for the most part less than one part per billion although the water in Jasper Park was an exception. Water from some deep wells was well fortified with iodine and from others the concentration was negligible. Unfortunately, there is as yet no complete agreement about the extent to which the iodine in well water can be used by the animal body. This much is certain, however, that wherever farmers have been obliged to use snow-water or water from dug-outs, the occurrence of goitre has been particularly noticeable and the need for supplemental iodine, correspondingly great.

Iodine Supplements

Tincture of iodine is the carrier that is known most universally and some attempts have been made to use it as a feed supplement. But to feed iodine this way is a mistake because tincture of iodine is a weak solution of iodine in alcohol and there are better uses for alcohol than giving it to farm animals. Iodine can best be fed to live-stock in the form of *potassium iodide*, a white crystalline product that can be obtained at any drug store for 25 or 35 cents an ounce. It may be mixed with salt or dissolved in water and added to the feed as a solution. Two ounces of potassium iodide dissolved in a pint of water, and the solution sprinkled over 100 pounds of dry, granulated salt, will iodize the salt adequately for use with sheep, cattle and horses. Some prefer to administer potassium iodide in a liquid form to mares as well as sows and to do that, one ounce of the iodide should be dissolved in a gallon of water and the liquid placed in a stone jar or stoppered crock; each mare in foal should be given one tablespoonful of the liquid on her feed daily for the last four or five months of pregnancy and each sow should get a tablespoonful of the same liquid twice or three times a week during the two or three months before farrowing. There are about 256 tablespoonfuls in a gallon of stock solution.

Iodine is one of the products that will, if fed in adequate amounts, be transmitted to milk and eggs in the normal course of production and thus enrich human food.

It appears probable that some individuals and some strains require more iodine than others. One may ask why an unusually

high incidence of goitre has occurred in the calves of the few West Highland cattle which have been introduced to Canada.

The opinion of a well-known Canadian stockman is of interest; his Highland grandfather stated repeatedly that the best Highland cattle in Scotland were raised close to the ocean and that it was not uncommon to see them eating seaweed. Seaweed is very rich in iodine, as is most vegetation grown close to the ocean. All animals may be considered as products of their environment and it is not unreasonable that here was a race of animals which had come to depend upon a comparatively high concentration of iodine in the feed. On account of that high content of iodine in the native vegetation, the power of assimilation may have been reduced with the result that when the cattle were brought to inland areas in Canada, iodine deficiency showed its effects.

A few words about commercially iodized salt would be timely. Stock growers have been able to buy block salt and housewives could get iodized salt in one or two-pound cartons. It has been assumed that the iodine contained therein would meet all requirements. Various reasons were given for the fact that the iodized blocks were usually of a brown colour; but salt that the farmer iodized was as white as the original product and he was inclined to enquire, "why the colour"? Was it because the colour suggested tincture of iodine, a product with which most farming people were familiar? Was it because the colour would conveniently identify the treated salt or were there other reasons? Perhaps another reason was the fact that the pigmentation hid the unsightly brown streaks that oftimes occured in iodized salt after it had been in storage for a period. At any rate, it was assumed that the colouring substance, usually an iron compound, was not injurious. It may not have been injurious to animals but iron, copper and magnesium compounds could hasten the loss of iodine from the iodized salt.

Time showed that the stockman had other worries in connection with iodized salt; it was found that iodine in salt was not stable and the iodine that was present when the salt left the factory might have disappeared in large measure after the blocks had been in storage for a period of time. Losses might amount to 40% or 50% in a storage period of 18 months. More than that, the original iodine content of 0.023% was considered to be low. All in all, there were cases of goitre reported in sheep flocks where commercially iodized salt was used. But men of science discovered a means of stabilizing iodine in salt; at first it was sodium thiosulphate developed at Wisconsin and then it was calcium stearate. Calcium stearate is a non-toxic insoluble soap, used extensively for water-proofing fabrics; 10 parts of the calcium stearate mixed with 90 parts of potassium iodide were

believed to give each particle of the latter a protective coating and thus prevent the loss of free iodine through volatilization or absorption by cardboard containers. Such a treated product was used with new confidence in mineral and feed mixtures. From a mineral mixture containing ferric oxide and copper sulphate as well as the treated potassium iodide and in storage for four months, the loss of iodine was less than 1 per cent. The soapy coating does not prevent digestion because the calcium stearate will be emulsified by the bile in the intestine. With the likelihood that an effective stabilizer will be adopted generally, there is also the prospect that salt manufacturers will increase the level of iodine in commercially iodized salt considerably above 0.023% which was a standard level for a long time. There are those who would like to see it raised to 0.05%.

Other Elements that May be Found to be Important. Time is likely to reveal new deficiencies. In some parts of the world a magnesium deficiency is recognized; in parts of Britain, magnesium sulphate (Epsom salts) has been fed to correct "grass sickness" in cows. *Copper* has biological significance in connection with iron metabolism, being concerned, not with the assimilation of iron but with the conversion of absorbed iron into haemoglobin. On Dutch pastures, where the grass yielded only 2 or 3 parts per million of copper (on dry weight basis) as compared with 7½ parts per million for healthy pasture grass, illness among the animals was noted; it was an illness which responded to copper therapy (*E. J. Underwood, The Significance of the "Trace Elements", Nutrition Abstracts & Reviews, Jan. 1940*). Salt sickness in Florida and Coastal disease in Australia have responded similarly. Stiffness in feed-lot lambs has been more prevalent since phenothiazine has replaced copper sulphate as a worm expeller and the trouble has been overcome when one pound of copper sulphate mixed with five hundred pounds of salt has been placed before the sheep.

Cobalt, classified as a "trace element" in the animal body is gaining new recognition in nutrition. Cobalt deficiencies in cattle and sheep were first identified in Australia and New Zealand where "wasting disease" occurred. In Scotland, cobalt is being recommended in the form of cobalt chloride to prevent or cure "pine disease" in sheep. Work done by the University of Alberta has pointed to the likelihood of cobalt deficiency in some sheep rations of Western Canada.

Zinc and *manganese* are other "trace elements" which have parts to play in nutrition. Wisconsin workers in 1934, showed that rats fed zinc-free diets made poor growth and had abnormal

fur. So far as humans or farm animals living under natural conditions are concerned, however, no zinc deficiency has been identified. *Perosis* or "slipped tendon" in poultry seems to be the product of manganese deficiency and victims usually die shortly. The same "slipped tendon" rations gave rise to eggs having poor hatchability and deformed embryos. Manganese fed to the laying hens or injected directly into the eggs prevented the deformities. The essential nature of manganese in the diet of man and other higher animals is still in doubt.

Conclusions about Mineral Requirements. The possibility of many mineral elements being required by farm animals has been considered but, by and large, the mineral constituents about which the stockman's thoughts should revolve are just five in number, *common salt, calcium, phosphorus, iron* and *iodine.* The need for additional amounts of mineral substances is a specific thing at any time and no mixture, either home prepared or commercial is likely to meet the needs of all farm animals, under all circumstances. Feeders of live-stock, quite commonly ask for a formula by which they can prepare a mixture that will correct all nutritional defects. Such "shot gun" methods cannot be practicable when nutritional requirements are specific. Attempting to correct all nutritional difficulties by feeding complicated mixtures would be like a sick man asking the druggist to include in one bottle a little of all the drugs in the store, hoping that something in the bottle would cure the unknown disorder. The effectiveness and value to the feeder of mineral supplements must always depend upon the extent to which they make good some deficiency in the rations.

The need for mineral supplements will depend on a number of factors, stage of maturity of the animal, nature of the rations and type of production to be supported. When good feeds and good management practices are employed, it is possible that all the mineral substances except salt will be supplied in the desired amounts, but feeders would do well to study rationing to ensure that the product which is needed is given when it is required. Mineral substances given when not required, represent waste and excessive amounts may be harmful. If the need is for iodine, nothing else will take its place and if the need is for calcium, additional phosphorus might do more harm than good. There is something to be said for the free choice system of feeding mineral supplements; an animal's instinctive choice is a good indication of its needs and when complicated mixtures are fed, too little or too much of one ingredient may be taken in order to satisfy the appetite for another. There is good support for the belief that under most circumstances, mineral supplements should

not be placed in commercially mixed grain feeds, but should be sold separately and rationed according to requirements.

Intelligent feeding calls for thought in determining those particular substances that are needed and for furnishing them accordingly. Mineral supplements will constitute an important spoke in the dietetic balance wheel; but it should never be supposed that mineral mixtures sold under fancy names can take the place of good feeds of the common kind.

"Morningside Queen Bess", Grand Champion Ayrshire cow owned by Cummings Brothers

CHAPTER XXXIV

VITAMINS

To make public utterances about vitamins a couple of decades ago was to invite the criticism of being "too theoretical" and 30 years ago, the word vitamin didn't even exist in the scientist's vocabulary. Today, folk discuss vitamins quite as glibly, at least with as much confidence, as they would discuss tomorrow's weather, or the outcome of the "world series". Vitamins have not been shorn completely of mystery but to a considerable degree, people have become vitamin conscious; that is good, but it does not follow that popular ideas about those vital food substances have always been well directed and free from illusions.

One of the common errors has been the supposition that because those various substances are called by the single group name of vitamins, they must possess marked similarity of make-up just as sugars are similar and amino acids. Actually, various vitamins may be no more alike than carbohydrates and fats; the characteristics they have most in common are late discovery and the essential parts which each must play in physiological welfare. Grouping them as was done at an early period, was often misleading and therefore unfortunate; each vitamin should be considered as an entirely independent food substance.

It would be convenient if the scientist could draw diagrams of the vitamins and thus make them more realistic; but that cannot be done and to the stockman they are likely to be known by name only. Furthermore, quantitative determination is still complicated and some of the vitamin substances cannot yet be determined by test-tube methods. Much of what we know of vitamins was learned by feeding experiments with the lower animals like rats and guinea pigs.

At any rate, vitamins are complex chemical substances, widely distributed in nature and essential to life and well-being in both man and beast. Gradually the number of known vitamins has been increasing; today we recognize A, B_1, B_2 or G, C, D, E, and some others. Further additions are almost a certainty. Each has its job to do in the body and its absence or an inadequacy will be marked by certain disorders or evidences of malnutrition. The amount required of any one is small but none the less vital.

The degree of stability in the various vitamins has given the nutrition worker new difficulties because it is one thing to know that a certain feed is fortified with the required vitamins and quite another to be confident that those substances are still available when the feed is eaten. While cooking and exposure to air are agents in causing reduced potency and value, digestive processes do not destroy the vitamins. Some of the vitamin value in feeds is conducted to the hen's eggs and the cow's milk.

In the refining of foods, much of the best in the vitamins has been removed and discarded and humans have suffered more than animals. Wheat flour is a glaring example and the craze for whiteness in flour is obviously inconsistent with good and

Carload of feeder lambs winning at Moose Jaw Feeder Show, 1929

practical nutrition. The germ and bran coats of wheat contain certain valuable vitamins and minerals but these must be removed and removed completely or the flour will not be acceptable to the trade. When a certain variety of wheat yielding a flour that carried a trace of colouring matter, a trace consistent with a better vitamin potency, was grown, the trade denied it better than a No. 3 grade. Indeed the craze for "top patent flour" is difficult to justify. Stock feeders have made mistakes but there is some mean comfort in the fact that they have not gone to such extremes as the bread eating public. Probably one of the greatest dangers of vitamin deficiency in humans will come when a high

proportion of the energy required by the body is taken in the form of highly refined foods.

Britain in the course of her wartime economy, saw fit to insist upon the refortification of wheat flour with certain needed vitamins and a calcium salt, and at least some of the flour sent from this continent carried synthetic thiamine (*Vitamin* B_1). The stockman is likely to ask why it was ever taken out of the wheat. Whole wheat flour would be more adequate for live-stock, including pigs, than white or refined flour would be.

Vitamins were as vital to animal welfare in the time of Amos Cruickshank and Robert Bakewell or for that matter, the time of Caesar, as at the present, but it was not until after 1910 that they gained scientific recognition. The story of discovery, when it is completely written will tingle with romance.

Scurvy and *beri-beri* were diseases that plagued the human race for at least 2,000 years; the cause was not well understood but occurrence was plainly associated with restrictions in diet. Beri-beri took great toll of human life in the Orient, especially where polished rice was a major article of diet and experimentally the disease was cured by the addition of these polishings to the diet. Scurvy was common in Northern Europe and was the particular scourge of the mariner in the years of sailing vessels, when long voyages placed weeks and months between the ship's crew and fresh foods. It was likely to overtake the sea-going traveller after he was a few weeks "out". It was discovered about the middle of the 18th century that citrus fruits would cure scurvy.

The Chinese knew of many foods which would prevent or cure night-blindness, and for generations the human mothers on the shores of Norway are said to have fed cod liver oil to their babies during the bleak winter months; why, they did not know, but science ultimately confirmed their judgment just as the judgment of the corn belt feeders who argued that yellow corn was better than white corn, was confirmed.

It was prior to 1912 that Hopkins of Cambridge gave the classical lead to nutrition workers. Up to that time it had been supposed that carbohydrates, fats, proteins and mineral salts in proper proportions would make a perfect diet but Hopkins demonstrated that a purified diet made up of starch, lard, casein and mineral salts, failed to produce health and normal growth in young rats, and that the addition of some whole milk seemed to correct the deficiency. The natural deduction was that whole milk must contain some essential, other than the recognized chemical constituents and Hopkins called the new something, "accessory food factor". In his report, he stated that "the animal

body is adjusted to live either upon plant tissues or other animals and these contain countless substances other than the proteins, carbohydrates and fats." Another worker about that time supposed the newly discovered substance was an *amine* and called it "*vitamine*" deriving the name from "vital amine". When it was shown later that the mysterious constituent was not an amine, the "e" was dropped from the term vitamine.

One by one, new vitamins have been discovered and gradually our knowledge of these nutritional factors has been extended. In the case of some of those vitamins, the exact chemical make-up has been determined and synthetic manufacture accomplished. There is yet much to be discovered about the vitamins.

Vitamin A

Vitamin A was the first to receive recognition (1913). It was described as a fat-soluble vitamin, necessary for health, reproduction and normal growth. But that was not all because it was to be shown that an inadequacy produced certain specific disorders, including night-blindness and another eye trouble called *xerophthalmia*; hence the term, "*antixerophthalmic vitamin*". In night-blindness, which occurs most commonly in cattle and pigs, vision in one degree or another of darkness is abnormally poor., But while eye disorders traceable to vitamin A deficiency are not wide-spread in either farm animals or humans, other results of shortage may be quite wide-spread.

It is of the greatest importance to know that a shortage of this factor results in reduced resistance to disease through changes that occur in the epithelial tissues of the body. In other words, this vitamin is responsible for maintaining the health of the layer of cells lining the digestive canal, respiratory tract and the outside of the body, and thus providing a wall of protection to keep trouble-making intruders out. Even in the case of poultry, it appears that colds are more prevalent and more severe where there is a deficiency of vitamin A. It may well become known as the "anti-infection vitamin".

The source of vitamin A is a yellow plant pigment called *carotene* but it is in the animal body that conversion takes place. Carrots, green foliage, cod liver oil, liver, yellow corn and milk and butter are rich in the vitamin or its parent substance. Usually much of the vitamin value of grass is lost due to oxidation in the course of hay making, but forages which are dried rapidly with a minimum of weathering are likely to retain a considerable potency and be of particular value for feeding to all classes of stock. Quick drying methods of making hay (artificially dried grass) and the use of phosphoric acid in making silage, have been popular in some parts of the Old World, and

in the resulting products there is a greener colour linked with higher vitamin potentialities. The carotene loss in hay is always greatest when haymaking is slow. It has been observed too that the older the hay, the lower its vitamin A value. Generally, the degree of greeness in hay is a good measure of its worth in vitamin A; this is a characteristic that the practical live-stock feeder should not overlook.

Vitamin A Deficiency. Canadian live-stock are not likely to suffer from vitamin A deficiency during the summer and fall months but in the course of the long winters, various classes of animals, notably growing pigs, calves that do not get colostrum, and milking cows are likely to be affected. There is a nutritional form of *scours* in calves, reflecting insufficient vitamin A, according to Wisconsin workers. In pigs, pneumonia may be more common and stiffness and lack of co-ordination may occur. Blindness in calves and in new born pigs has been traced to the same deficiency. Work in Denmark, England, and on this continent has shown that a continued lack of vitamin A can lead to serious injury to the central nervous system with muscular inco-ordination and paralysis. In less advanced cases, according to work done at Reading, pigs show a behaviour similar to that which has puzzled Canadian growers;

> "Diminished appetite was the first abnormality. The pig became lethargic and dirty in the coat. The eyes became somewhat protuberant. Often the head was held on one side with one ear drooping and the other cocked up . . . The gait became abnormal, the hind legs were stiff and small, awkward steps were taken. At this stage a complete nervous collapse occurred in several cases. This was frequently brought on by a convulsive fit. The pig staggered and fell on one side."

They concluded that the inclusion of ½% of cod liver oil in relation to the grain fed was sufficient to safeguard the pig against all the disorders associated with vitamin A deficiency.

Cows' milk is either rich or poor in vitamin A, depending upon the nature of the ration, and good rations for dairy cows would seem to be one way by which milk for human consumption might be fortified or "vitaminized". It is estimated that by feeding the best quality of silage in which carotene is preserved, the vitamin A value of milk would be 50% better than average for winter milk. Colostrum is richer in vitamin A than later milk which further emphasizes the importance of ensuring that the new born calf gets the first milk.

Fortunately there can be considerable storage of this factor in the body, chiefly in the liver, where up to 90% of the body reserves may be held. The lungs too, in which the factor is

capable of doing so much good, are the seat of considerable storage. Resistance to heat and cooking is fairly good but oxidation and drying will destroy the vitamin quickly. Exposure to the air of feeds carrying vitamin A results in serious loss in value. Cod liver oil in a well sealed container will retain its vitamin A potency for many years but when placed in a feed mixture with grains, the "A" value will be lost very largely in a matter of a few weeks.

The "B" Complex

The originally recognized vitamin B is now known to be a complex consisting of many factors, *thiamine* (B_1), *riboflavin, niacin, pantothenic acid, biotin, pyridoxine* (B_6), *choline,* and others.

Vitamin B_1. Early workers called vitamin B the antineuritic factor because it was found to prevent or cure polyneuritis in birds and beri-beri in man. But what was formerly called vitamin B is now known to be a complex consisting of many vitamins. The antineuritic factor or vitamin B_1 is now known as *thiamine,* while one of its team-mates is B_2 or G. There is definite evidence

Courtesy Ontario Live Stock Branch

A champion pen of Chester White barrows, a breed no longer popular in Canada

that thiamine is required in poultry, rats, dogs, calves and humans; and in the case of such animals as the mature cow, it is known that vitamin B_1, like some other members of the B complex,—riboflavin, niacin, pyridoxine, pantothenic acid and biotin—, is manufactured by bacteria in the first stomach compartment or rumen, and perhaps the colon. Thus cattle and probably other large animals are able to accommodate their own requirements for this food factor; as one would expect, cows' milk remains fairly constant throughout the year as a carrier of B_1 and it may contain 10 times as much riboflavin as the feed eaten by the cow. New functions have been found for B_1; a deficiency has been observed to produce poor appetite, diminished powers of digestion and absorption, slow growth and perhaps lowered breeding efficiency in both sexes. Thiamine along with other members of the "B complex" is often needed above normal allowances by calves on milk substitutes, and a deficiency may result in scours. Calf meals to be used as a milk substitute should include some brewers' yeast. Someone has called thiamine the "spark plug" vitamin because it supplies the "spark" to help in the conversion of food to energy. It may well have a big part to play in digestion and assimilation, and certain types of constipation in humans are traceable to a deficiency of it.

Yeast is a rich source of this vitamin and so are grains, fruits, milk, vegetables and meats. In the case of grains, most of the vitamin B_1 is in the outer coats which, in wheat, are removed as germ, bran and middlings in the milling of flour.

Body storage is small and therefore B_1 must be provided with regularity. Storage is mainly in the liver. The vitamin resists drying well but has only medium resistance to heat. Cooking losses depend to some degree upon the methods employed; from Wisconsin studies it appeared that there was a 25% loss of the vitamin when meats were fried, 50% loss from boiling and 60% loss from roasting. Where an alkali like baking soda is added in the cooking process, the destruction of B_1 is greatly increased.

Vitamin B_2 or G. What has been designated B_2 contains at least three nutritional factors of practical importance, one for growth, one for the prevention of pellagra and one for the prevention of a skin disorder or dermatitis in rats and chickens. Pellagra was prevalent in the United States, especially in the poverty stricken parts of the south and in severe cases, fully 50% were fatal. Cambridge and Pennsylvania State workers have shown that pellagra can affect pigs and that the disorder in that class of animals can be corrected by good rations or by administration of nicotinic acid or *niacin*. Administration should be at the rate of 10 to 15 milligrams per 100 lb. of pig daily. But Canadian

experience has not shown any wide-spread deficiency of vitamin B in pigs and it is assumed that the feed grains in common use supply the pig's needs for niacin as well as for thiamine.

Nicotinic acid now more correctly called niacin, which Wisconsin workers, Elvehjem and Madden, showed to be the pure form of the anti-pellagra vitamin, can be made from nicotine but it does not follow that the use of tobacco would prevent or cure pellagra; such is not the case.

The anti-dermatitic factor is being called *pantothenic* acid, and is essential for humans and many animals.

The growth factor in vitamin B_2 is chemically, *riboflavin.* Poultrymen have discovered it to be necessary for hatchability. Failure in the case of such deficiency is due to the death of the embryos before hatching. The flavin content of eggs is consistent with the flavin present in the hens' diet and the riboflavin reserves of the newly-hatched chick's body may also depend upon the hen's diet. Feeds rich in riboflavin include yeast, liver, milk, meat and green forages. Resistance of riboflavin to heat and drying is good but its body storage quality is not great.

The lack of what is called vitamin B_4 produces a type of paralysis in chickens. In the early stages the birds lift their legs unusually high, like a stringhalt horse. This factor like other members of the B complex, is found abundantly in meat products, especially liver and kidney. Vitamin B_6 (*Pyridoxine*) is specific along with pantothenic acid and linoleic acid for the prevention of a condition called acrodynia, a severe dermatitis in white rats.

Vitamin C

The stockman isn't likely to have more than an academic interest in vitamin C because most animals either do not require it or they have the faculty of manufacturing it; man, monkey and the guinea pig are exceptions however, and these will develop scurvy if vitamin C, the anti-scorbutic vitamin is not supplied. Chemically, the vitamin is ascorbic acid and it is one of the feed factors which the chemist has been able to produce in the laboratory. Healthy people with a good reserve of vitamin C have 0.8 to 1.0 milligram of ascorbic acid in 100 milliliters of blood. It is when the level goes much below 0.4 milligram that real scurvy might develop, but borderline deficiencies may mean fatigue, ill temper, increased tooth decay and lowered resistance to disease. In the case of certain diseases such as tuberculosis, colds, diphtheria and tonsilitis, the vitamin C requirement of the body is increased considerably. The amount of vitamin C consistent with the best degree of health is much above that which would barely prevent scurvy.

Scurvy held terror for ocean-going travellers in the years of sailing vessels. It produced suffering and death among the Selkirk settlers who were going to Western Canada to make homes and it took toll of lives in exploration parties that went into the polar regions. It was a dread thing, marked by pains in the joints, tooth troubles, bleeding gums, and hemorrhage.

Vitamin C is widely distributed in nature; milk, however, is not a reliable source and some that is present in fresh milk is lost in pasteurization by ordinary methods. Citrus fruits are a rich source and tomatoes, green forage and leafy vegetables furnish it in abundance. The trouble is that vitamin C is not highly resistant to either heat or drying and body storage is slight.

Vitamin D

While the farmer is not greatly concerned about vitamin C, he has a very deep interest in the anti-rachitic factor, vitamin D. Vitamins A and D, both fat soluble, were discovered to be together in 1922; it was shown that when vitamin A in cod liver oil was destroyed by oxidation, the oil was still able to prevent or cure rickets, indicating that a second factor was present.

Vitamin D shares with calcium and phosphorus, the responsibility of building and maintaining bone. In the absence of this vitamin, the bone building elements calcium and phosphorus are not utilized, even though they be present in the diet. Any retardation in the metabolism of bone, be it an insufficiency of the bone building material, an unfavourable balance between calcium and phosphorus or a shortage of the vitamin, will result in weakened bones and one form or another of rickets. If calcium or phosphorus be not present in adequate amounts, the need for vitamin D in the ration is increased. Optimum calcium and phosphorus would seem to account for those instances where a Canadian grower has appeared to raise fall pigs successfully through the winter months without recourse to cod liver oil or other vitamin D supplement. In young animals the bones will be soft and often misshapen by the weight of the body and in older ones, the bones will be porous and weak and more easily fractured. There are low phosphorus and low calcium types of rickets and both may occur in farm animals. The incidence of the low phosphorus type is significantly high on account of the fact that phosphorus is present in muscle tissue and hence additional need in the case of quick growing animals.

Such disturbances in bone building and bone restoration are rather wide-spread especially among young pigs and calves during winter months. The same type of disorder is prevalent among undernourished children. In the case of rachitic calves

which are receiving milk, the deficiency is almost certainly one of vitamins rather than mineral material, while in winter pigs, both vitamins and mineral substances may be involved. Vitamin D is also a factor in securing strong shells and hatchability in hens' eggs and normal growth in all animals.

Too much vitamin D is possible and the result seems to be an excessive deposition of lime in arteries and body organs. It is not likely however, that excessive intake of vitamin D has resulted in any considerable loss to stock owners.

Sunshine

An animal's vitamin D requirements can be met through the use of selected feeds or through the action of direct sunshine upon the skin. The action of sunshine upon *ergosterol*, a substance which is present in the skin, produces vitamin D. Any product which carries a lot of ergosterol, will if irradiated by sunshine or a quartz mercury-vapour lamp, have increased vitamin content. It is the ultra violet light or part of the light which makes irradiated foods richer in the vitamin. Yeast, milk and other human food products are not infrequently irradiated. Cows in milk during winter months have been given irradiated feed with definite response and if exposed to ultra violet light from a lamp, there is a noticeably greater quantity of vitamin content in the milk. Cows' milk, therefore, will be better for human consumption and for calves, if vitamin rich rations are fed or if the cows are exposed daily to sunshine.

Mid-day sun is most effective and summer sunshine is stronger and better able to induce the vitamin than is winter sun. The rays lose most of their effectiveness when they strike the earth at an angle of less than 35° with the horizontal, which means that early morning or late evening sun is ineffective and sun of the entire day during November, December and January in Canada is not very helpful. Nor do the ultra violet rays from the sun shine successfully penetrate ordinary window glass or a smokey atmosphere; the practical implications will be recognized immediately. Any sunshine that will cause sunburn on the human skin will most certainly produce the vitamin. The colour of the skin is a factor however and negros living in northern areas will be handicapped.

Vitamin D is distributed widely in natural feeds although in most cases its concentration is not great. Sun-cured hay that has been carefully made is a valuable source for cattle and indeed it may be even richer in vitamin D than the fresh green forage. Whole milk from well fed or irradited cows is a valuable carrier and as a supplemental product, fish liver oil is used universally. Cod liver oil and pilchard oil are most common and those oils

of guaranteed vitamin content are likely to give perfect satisfaction. The student must be interested in the fact that cod liver oil rubbed on the outside of the animal body has definite anitrachitic effect. Excessive amounts of cod liver oil given to milking cows will cause decline in butterfat test, however. Concentrated forms of the fish oils are on the market for both human consumption, and live-stock feeding.

Vitamin D has been isolated as a crystalline substance called *calciferol.* It is more stable than vitamin A, being more resistant to both heat and the action of air. When cod liver oil is mixed with feed, the vitamin A value is dissipated quickly while the D content persists.

Farm herd of Shorthorns on native parkland pasture

Vitamin E

The existence of vitamin E (*Tocopherol*) was established by Evans and Bishop of the University of California and others. It was believed that an absence of this food factor caused temporary sterility in female rats and permanent sterility in the male. In the females in the experiments, fertilization occurred normally but the embryos died at about 13 days after conception. The vitamin is described as fat soluble and one that withstands cooking rather well, but is destroyed by rancidity in the fats in which it occurs. It is now supposed that the purpose of tocopherol in the body is to ensure muscular functions and that early

workers associated it directly with sterility because in the case of the rat, the muscles of the uterus were the first to be affected.

This food factor is distributed widely in nature and it is not certain that deficiency has actually caused significantly widespread sterility in farm animals. It is present in large amounts in grains and green forage; wheat germ oil and wheat germ meal have it in concentrated amounts and the oil has been used with what has seemed to be encouragement in connection with efforts to correct certain forms of breeding troubles in farm animals. Indeed, the vitamin E is so widely distributed in feeds that its purchase in concentrate form is of doubtful necessity and the breeding advantages claimed for wheat germ oil are probably overstated.

Conclusions

There are other vitamins, some discovered and others yet to be identified. There is the chick antidermatitis factor or *pantothenic acid* to which scant reference has been made; there is *vitamin K*, the anti-hemorrhagic vitamin of which green alfalfa is a good source; there is "H", the factor which is curative for egg white injury and present in yeast and liver, and we hear of a factor which prevents graying or the occurrence of gray hairs in foxes. There must be others. Just how many of the food factors needed in the body are manufactured there, we do not know. It is known that bacteria in the paunch of cattle can convert urea to protein, that the same cattle can synthesize vitamins of the B complex, and that rats and chickens can construct their own niacin. To what extent man can build some of the vitamins he needs is not fully understood.

Through the revelations of science, man is in a better position to ration intelligently for himself and his animals. The folly of refining foods very highly and sacrificing certain valuable food factors is now clear. The ridiculousness of refining wheat flour to a high state and thus losing most of the thiamin, 80% of the niacin, 50% of the pantothenic acid and B_6, when compared with whole wheat flour, must be striking.

Just what is the practical significance of the newer knowledge of vitamins? As those food substances are becoming better known, it is clear that their part is far-reaching in the welfare of humans and live-stock. It is not too much to say that the discovery of their secrets has revolutionized the science of nutrition and had a rather revolutionary effect upon medical practice. How many physical disorders and abnormal forms of human and animal behaviour will yet be found to be related to nutrition and vitamins, no one can tell. It is now suggested that even mental welfare may be more closely allied with nutrition than previously

supposed, and that the lad or lass who "isn't getting along so well at school" may be a sufferer of one of those obscure forms of starvation. But until science can set these disorders and their correctives up in their true perspective, variety in the diets of animals and humans, would seem to hold the greatest hope.

It is estimated that the people of the United States spend $75,000,000 annually on "drug store" vitamins and stockmen may be inclined to provision their animals by somewhat the same plan. To a degree, that is right and justifiable but there is too great a tendency to overlook the fact that most requirements can be accommodated by good and varied rations within the reach of a majority of stock owners.

Standard Vitamin Units. The vitamin units which are becoming standard follow:

Vitamin A. One International Unit (I.U.) is the equivalent of 0.6 micrograms of pure B-carotene. (One microgram or gamma is one-thousandth of a milligram and one milligram is one-thousandth of a gram. There are approximately 28 grams in an ounce.)

Vitamin B_1. Three micrograms of thiamine hydrochloride constitute one International Unit of vitamin B_1.

Riboflavin. The vitamin concentration in this case is commonly expressed as milligrams of riboflavin in 100 grams of feed.

Vitamin C. An International Unit consists of the equivalent of 0.05 milligrams of ascorbic acid.

Vitamin D. The International Unit is one milligram of a solution of irradiated ergosterol which is supposed to be equivalent to 0.025 micrograms of crystalline vitamin D.

Good cattle and good grazing at Ballindalloch, Scotland

CHAPTER XXXV

PRINCIPLES OF DIGESTION

The machinery of digestion is not nearly as mysterious as some people suppose and many of the processes can be described in comparatively simple terms. Certain lowly forms of parasites, particularly those living on simple foods, are constituted without digestive tracts and therefore can never know the tortures of dyspepsia. Tape-worms, for example, are able to absorb food from the material in which they are submerged, food digested by the host. But in the higher animals the feeds are more complex in constitution and the cow that could not eat would starve to death as fast while lying in a bed of hay as she would if isolated from feed. In the higher forms, nature has considered it better to use the outer surfaces of the body for protective purposes rather than food absorption. Besides that, the feed of the larger animals must be changed greatly before it can be put to use within the body.

The cow may be regarded as a milk factory or a meat factory and an examination of her digestive tract will reveal a number of points in common with the modern manufacturing plant. In this meat and milk factory there is a receiving department through which raw materials enter the factory; there is a processing department in which the raw materials are changed or made over; there is a distributing department from which the materials are diverted to various parts for storage, production, and for the maintenance and repair of the factory; finally, there is a back door from which waste materials are removed.

Herbivorous animals like the cow, sheep and horse have the most difficult task in converting raw materials as their task is to change vegetable matter to energy and animal matter; this obviously, is a much more difficult task than the conversion of meat to meat as in the case of a carnivorous animal like the dog. What makes it doubly difficult in the case of herbivorous animals like the horse, cow and sheep is the fact that the particular vegetable foods which they eat are usually quite high in that tough and resistant constituent of feed called fibre. Meat-eating animals do not have that fibre to contend with.

In the work of digestion changes must be made in the mech-

anical and chemical states of feeds; in the higher animals one of the first requirements is that the feed be reduced to a degree of fineness in physical texture, although in some lower forms of animal life including certain snakes, the mouth and digestive tract can be distended to accommodate large portions of food material which would normally have greater diameter than that of the animal itself. Snakes have been known to swallow cats which were fully twice as big in diameter as themselves.

The Teeth

In the case of the frog, which so many high school students study, the worms, bugs etc., upon which it feeds are seized with its sticky tongue and when brought into its mouth these objects of food are held temporarily by small teeth on the upper jaw only and by pressure caused by the eye-balls being drawn down upon the mouth cavity. No one can say that Nature does not examine all the possibilities in the course of evolution. Notwithstanding these observations, in the animals of the farm the food is chewed in the mouth and at the same time moistened by saliva before being swallowed. The teeth of animals bear a certain relationship to the type of diet that is natural to them. For example, the carnivorous animals have teeth that are sharp and erect, suitable for tearing flesh but not for masticating tough foods. The ox and the horse on the other hand have broad, flattish teeth with corrugated surfaces, excellent for grinding fibrous material.

The horse has 12 biting teeth called "incisors", 24 grinding teeth called "molars" and in the case of the males there are four canines. The canines might be a remnant of a former age when the horse was omnivorous in feeding habits. At any rate he doesn't use them today. The sheep and the cow have 24 molars and 8 incisors, the latter being on the lower jaw only. The sheep has a pad on the upper jaw which serves in conjunction with the lower incisors for biting grass and such feeds. The cow, however, is obliged to use her tongue to a greater extent in taking grass and other roughage into her mouth. It is not surprising, therefore, that sheep graze much more closely, than the ox and that there were range wars when sheep bands invaded the cattle country in years gone by. The pig has 12 incisors, 4 canines, and 28 molars.

Mastication

The ox masticates rapidly and has developed the faculty of bringing the food back to the mouth for a second mastication when time and opportunity permit. The rabbit lives on fibrous foods and does not ruminate; it has another trick. It may receive

pellets of faeces directly from the anus during the night and then repeat the digestive action. The horse masticates comparatively slowly but thoroughly, while carnivorous animals do not have to masticate much at all. Since theirs is a meat diet, it seems to be necessary only that the food pieces be sufficiently small for swallowing.

Actually food must be subjected to three forms of digestive attack, mechanical, chemical and bacterial, in the organized attempt to reduce the material to relatively simple compounds for absorption and use in the "factory". Even pure protein, or butter, or sugar, of the kind that appears on the table is too complex chemically to be taken by the intestines whose job is to absorb the digested material. The chemical attack is by means of enzymes, substances with which the laymen is not likely to be familiar. Enzymes belong to an interesting group of products not very versatile but tremendously effective.

The Enzymes

Enzymes are very fussy about the circumstances under which they will work. Moreover they are specific in their action; some act upon carbohydrates, some upon proteins and some upon fats; some act in an acid medium and some in an alkali medium; high temperatures will destroy them and while freezing will halt their action it does not destroy them. They act best in an environment close to the body temperature of the higher animals. Their job is to produce and hasten chemical changes, mainly to hasten the reduction to simple compounds of those substances which the intestines could not otherwise absorb. The enzyme *ptyalin* in the saliva, to which the food material is exposed when being chewed, converts starches to a form of sugar called maltose; the *pepsin* in the digestive juices in the stomach attacks the protein molecules, breaking them down to simpler forms and the various enzymes from the pancreatic gland, *trypsin, amylopsin* and *steapsin*, are released into the small intestine to be used in reducing protein, carbohydrate and fat respectively to simpler states. There are other enzymes in the intestinal tract but only the above need be mentioned at this point.

The student of digestion is familiar with the existence within the body of *co-enzymes* and *anti-enzymes*. Co-enzymes assist the work of the digestive agents; bile from the liver serves such a purpose. Anti-enzymes counteract enzymatic action and if it were not for the presence of these substances in the stomach wall for example or the bodies of internal parasites, those would be digested by the stomach or intestinal juices.

The saliva has two or three purposes,—the moistening of the food, the supplying of a starch-splitting enzyme and in the case

of the ruminant, supplying sodium bicarbonate which checks over-acidity in the rumen. Three pairs of glands, *parotid*, *submaxillary*, and *sublingual* supply the saliva to the mouth. (When the farm boy goes down with mumps, by the way, it is the swollen parotid which causes the unpleasant enlargement). Each gland is connected by a duct and stimulation seems to be under nervous and physical control. The presence of food in the mouth and the sensation of eating reflexly stimulate secretion; dry food will stimulate more than moist food. Furthermore, the thought, sight, or smell of attractive food will produce a similar type of activation. Fear or nervousness will retard the flow of this or other digestive juice; indeed there are those humans who know too well that fear and nervousness can produce indigestion. A mature horse will produce 80 to 100 pounds of saliva and a cow 100 to 125 pounds in 24 hours. Ptyalin is the only digestive enzyme in the saliva and seems to be prominent only in the saliva of humans and other omnivora although there may be a slight amount in the saliva of herbivorous animals.

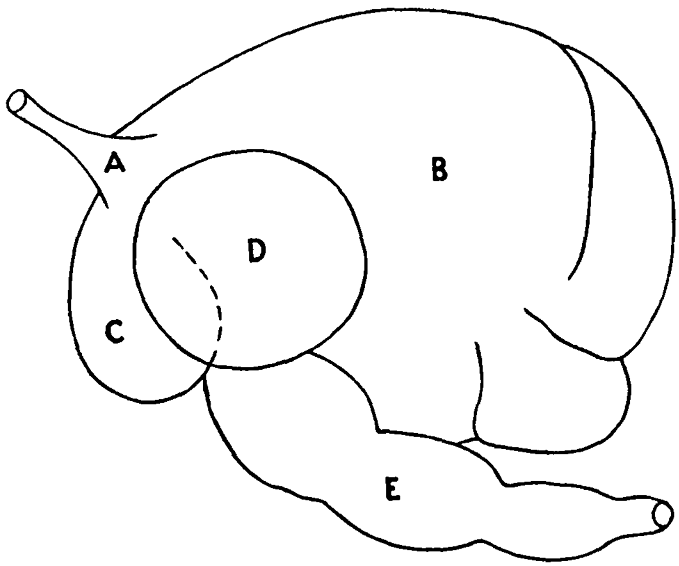
Stimulation for the swallowing act is produced by the presence of food material in a certain state of fluidity and fineness in the back part of the mouth. It is easy to demonstrate the difficulty of swallowing foods which are too dry or not sufficiently broken up. A drug store pill can be employed for a demonstration. The swallowed food is conveyed to the stomach through the *oesophagus* or *gullet*, partly by gravity and partly by "peristaltic" or travelling contractions which are capable of conveying the food material even though the animals' mouth is lower than the stomach as would be the case with horses eating grass or drinking water from a stream. In other words, swallowing can be accomplished against gravity.

The Stomach

The stomach may be regarded as an enlargement of the alimentary canal with purposes of storage and partial digestion. The wall is composed of four layers; from the inside they are *mucous*, *submucous*, *muscular* and *serous*. In the stomach the food is halted for more concentrated attack upon those portions which the organism may use. Many and strange have been the theories expressed through the ages about the workings of the stomach, and it was little more than 100 years ago that science began to cast some light upon the truth. Indeed, some of the credit must go to a French Canadian living in the New England States; Alexis St. Martin was addicted to drink and in the course of one of his sprees, a shot-gun was accidentally discharged blowing off part of his abdominal wall and part of his stomach. He came under the care of a bright young doctor, William Beau-

mont. And while there was little hope for the patient's recovery, the doctor did the only thing that seemed possible; he stitched the stomach and abdominal wall together leaving an opening requiring a "lid" into the stomach. Ignoring all precedents, the French-Canadian lived and Beaumont tried to adopt him as an experimental subject. When he behaved, and remained sober, St. Martin was a splendid "guinea pig".

Nevertheless, the Doctor satisfied himself about a number of things; when he peered into St. Martin's digestive cavity he was able to observe stomach movements; when he suspended a piece of meat on a string and placed it in the stomach, the meat became partially or completely dissolved, depending upon the length of time it was left there. He noticed that stomach juices were present when food was being eaten or when it entered the stomach, and when he siphoned some juice away from the St. Martin stomach, the discovery was made that it contained hydrochloric acid. In 1833 Beaumont published the results of his experiments and observations, casting new light upon man's



Outline of cow's stomach:

A—Oesophagus.
B—Rumen.
C—Reticulum.
D—Omasum.
E—Abomasum.

knowledge of the physiology of digestion. St. Martin, so we are told, lived on for another forty-seven years in spite of his handicap. When the Frenchman did ultimately die, William Osler then Professor of Physiology at McGill sought to obtain St. Martin's stomach but Mrs. St. Martin said no and gave instructions that the grave be a deep one.

The horse has a simple stomach, comparatively small, with a capacity for about four gallons. Ruminants have complicated stomachs in which there are four well-defined compartments, technically described as *rumen, reticulum, omasum* and *abomasum.* The stomach of the ox may have a capacity as great as 45 gallons or just about the equivalent of a rain barrel. In the the mature animal, 80% of that capacity is in the first compartment, (rumen or paunch), 5% in the second (reticulum or honeycomb) 7½% in the third, (omasum or manyplies) and 7½% in the fourth (abomasum or true stomach).

DIGESTIVE AGENTS IN ALIMENTARY TRACT

Secretion	*Enzyme*	*Other Agent*	*Purpose*
Saliva	Ptyalin		Changes starch to maltose
"		Alkali	Facilitates work of ptyalin
Gastric juice	Pepsin		Reduces proteins
" "	Rennin		Coagulates milk
" "	Gastric lipase		Breaks down fats partially
" "		Hydrochloric acid	Permits the work of pepsin
Pancreatic juice	Trypsin		Reduces proteins to simpler compounds
" "	Amylopsin		Converts starch to maltose
" "	Steapsin		Reduces fat to glycerine and fatty acid
" "		Alkali	Helps to neutralize HCl in chyme and to saponify fats
Bile		Bile salts	Assists the action of steapsin and helps neutralize HCl
Succus entericus	Erepsin		Reduces proteins to amino acids
" "	Invertase		Changes sucrose to glucose and laevulose
" "	Lactase		Changes lactose to gallactose and glucose
" "	Maltase		Changes maltose to glucose
		Bacteria	Act upon Cellulose

Accordingly, four-fifths of the capacity of a cow's stomach is in the first compartment but in early calfhood, the fourth or true stomach is the largest. At about one and one-half years of age the permanent relative size of compartments is attained. Indeed, investigation has shown that the total capacity of all the stomachs of a new-born calf will be equal to only five pounds of milk. The error has been made too often of trying to get a two-day-old calf to drink something more than half a gallon at one time, resulting in some of the milk being forced on into the intestine before the stomach was through with it, causing indigestion with scours, so common in pail fed calves.

It is now known that certain feed substances can be synthesized in the digestive tract of ruminants and such synthesis is believed to be accomplished mainly by bacteria in the rumen. Many of the vitamins of the B complex, riboflavin, pyridoxine, pantothenic acid, biotin and some others are known to be produced in the rumen. Rumen bacteria can also convert non-protein nitrogen to bacterial proteins of good biological value, which gives ruminants a distinct nutritional advantage under some circumstances. The theory is now advanced that regardless of source, much of the protein used by ruminants, comes through bacteria.

Rumination

Feed material delivered to the first stomach compartment of the adult ox or sheep may be held a considerable time and exposed to conditions of moisture and temperature which favour bacterial development and bacterial attack. It is also from this first compartment that the ruminant withdraws the food for further chewing, a most convenient and sensible although somewhat anti-social arrangement. This process of rumination or chewing of the cud is made possible by the withdrawal of a bolus of food and its movement up the oesophagus as required. The withdrawal of the bolus from the stomach seems to be accomplished by an inspiratory effort against a closed glottis. In other words, the ox is able to enlarge his thoracic cavity as he would in normal inspiration but prevent the inflow of air past the glottis so that a partial vacuum is set up in the thoracic cavity. Since the gullet or oesophagus is a soft walled organ, it is entirely consistent with natural laws that some of the food material in the stomach would move into it and then be carried back to the mouth by peristaltic contractions working in reverse. An ox will chew its cud for approximately eight hours out of twenty-four, chewing each bolus about one minute; at least that is the opinion of one who sat upon a bale of hay and counted, all in the name of science. After the second chewing,

some of the food may remain still longer in the rumen while some will pass on to the third stomach.

Bloat

In the case of "bloat" in ruminants, it is the rumen which is distended with gas. It was long supposed that certain feeds such as green alfalfa tended to produce excessive amounts of gas and therefore were most likely to cause bloat. Important work reported in 1942 by H. H. Cole, S. W. Mead and Max Kleiber, (*Bloat in Cattle, Bul. 662, Feb. 1942, U. of California*) showed that "bloat is not caused by excessive gas formation but by interference with belching". Gases, mostly carbon dioxide, methane, oxygen and some others, are produced quickly after feed is taken into the stomach, through the action of bacteria, yeasts and other micro-organisms.

But the studies showed that green alfalfa which is considered a common cause of bloating in cattle, produced no more gas than alfalfa hay. The conclusion seems justified that a certain amount of gas formation in the rumen is normal and that belching is also normal. When belching is interfered with, either by an excessive weight of succulent feed on the floor of the rumen or an absence of enough fibrous material of a prickly nature to produce the necessary reflexes, the normally generated gases accumulate causing distention, distress and perhaps death. Some coarse roughage may therefore be needed by ruminants and feeding some hay to cattle before turning them on legume pasture for the first time is still the best practice.

After the second or third chewing, food passes to the manyplies or true stomach of the ruminant. The second stomach or honeycomb never has much feed material in it. Its contents are usually liquid and it is thought that by contracting, its fluid serves to moisten the feed boluses which are about to pass up the oesophagus for remastication.

This second compartment serves another and equally interesting purpose; whether by design or accident, it seems to function as a catch-basin, because heavy articles including stones, nails, wire, etc., that may be swallowed, accumulate here and remain indefinitely. There is always a surprise for one who examines the contents of the reticulum, especially if the animal, cow or bull, has spent many years around an untidy barn-yard. There is always the possibility, too, of a nail or other sharp object working through the stomach wall and the diaphragm and piercing the pericardium which is the sac which surrounds the heart. Sudden deaths, among cows particularly, have been traced to that. Before leaving the discussion about the compartment which holds the "junk-pile", it should be recorded for the

benefit of those rare individuals who eat tripe and contend they like it, that the best tripe comes from the reticulum.

The third compartment or manyplies, is equipped with numerous inner folds or leaves which must function in the holding and grinding of fibrous feed. Those inner folds are of three sizes, large, medium and small, and occur alternately. It is a mysterious organ; it is always full and hard. This hardness has deceived many amateurs who have undertaken to conduct a post-mortem on a dead cow. When the hard organ was encountered, it was concluded incorrectly that the cow died of impaction. The hard, compact condition of that organ and the dry nature of the contents are entirely normal and close examination of the contents will show that the feed material contained therein is much finer in texture than anything in the other compartments. On the other hand, it is not impossible that some finely divided feed passes directly from the first to the fourth stomach thus missing the omasum completely.

The True Stomach

The fourth or true stomach of the ruminant is the only one which secretes digestive juices and these are similar to those in the simple stomach of the horse or, for that matter, the pig. Numerous folds occurring on the inner lining of the true stomach, greatly increase the inner surface, and secreting area. Collectively the digestive juices of the stomach are called *gastric* juice and the principal enzyme is pepsin which accomplishes the work in the presence of hydrochloric acid, also secreted in the glands of the stomach wall. Gastric juice has a hydrochloric acid content of between 0.3% and 0.6%.

In the case of the horse, more than the ox or sheep, feed material entering the true stomach remains in layers or strata and passes through in a rather orderly way. That portion which is held high in the stomach will be subjected to secretions containing nothing more than mucous. There the saliva from the mouth may continue to act upon the food material before it makes contact with the hydrochloric acid. It may be recalled that the ptyalin in the saliva, acts upon starch in an alkaline or neutral medium but not in acid. As the food settles down in the simple stomach it becomes exposed, first to the hydrochloric acid and ultimately to the powerful protein-splitting enzymes.

Two other enzymes may be present to act upon the feed in the stomach. One is *gastric lipase* which has a slight digestive action upon the fats, particularly that fat which is in an emulsified form, milk fat for example. The other enzyme prominent in the stomach of the young animal is *rennin.* Rennet which is extracted from the calf's stomach is used in cheese manufacture,

and the function of the rennin in the young stomach is to coagulate the milk and thus halt it for digestion.

Gastric juice does not flow continuously; it flows when it is needed. The presence of food in the stomach will stimulate the secretion of the hydrochloric acid and the pepsin. Like saliva, the flow of gastric juice responds to psychological stimulus. In other words, the prospect of food or the thought, sight or smell of good food will speed the flow; it is not a myth that the mouth "waters" when good food is being served and it is equally true that the stomach can "water" under similar circumstances. Actually therefore, man or animal will digest food more completely if the rations are attractive and appetizing.

The outward passage of food from the stomach bears a relationship to the fullness of that organ, movement being slowest when the stomach has but little in it and fastest when it is full. Some observers have noted about the horse that when the stomach is two-thirds full the inward and outward movements are about equal. The human stomach, curiously enough, is nearly always full because it enlarges and contracts to accommodate its contents. When there is but little food in the human stomach, the organ assumes small proportions and it is then that hunger pains or more violent peristaltic contractions can sometimes be felt. The outward passage of the food material into the intestine occurs intermittently and is controlled by a strong sphincter called the *pylorus*. It should be noted that there is no appreciable absorption of food material from the stomach; not even water is absorbed from that organ. Water, by the way, does not remain long in the stomach. It passes into the intestine from which it is absorbed quickly.

The Intestines

Food material after leaving the stomach must pass through a great length of small intestine and then a shorter large intestine before being voided from the body. Digestion is not completed in the stomach and no absorption occurs there. To those tubular organs which seem to occupy a large portion of the abdominal cavity, nature has assigned the dual function of digestion and absorption.

As the partially digested food or *chyme* passes from the stomach to the intestine, it is exposed immediately to further digestive agents, *bile* which has been classified as a co-enzyme, and *pancreatic* juice which carries three powerful digestive agents. These two secretions are brought to the intestine by two ducts which terminate rather close together in the duodenal region. Bile is secreted or excreted by the liver, stored in the gall bladder and released into the intestine to serve several pur-

poses; bile is alkaline and helps to counteract the acidity resulting from hydrochloric acid in the stomach; it facilitates fat digestion by emulsifying and saponifying the fat in the food, and finally, it is thought to have an antiseptic effect which checks putrefaction. If, on account of the formation of gall stones in the bladder or any other such reason, there is a stoppage of the bile, the faeces are likely to have a foul odour reflecting excessive putrefaction. The bile is a greenish liquid and is sticky.

Pancreatic Juice

The pancreatic juice, containing three strong enzymes, is secreted by the pancreatic gland and poured into the small intestine quite close to the stomach outlet. The enzymes are *trypsin, amylase,* and *steapsin,* whose purpose it is to split or reduce protein, carbohydrate and fat materials respectively. Pancreatic juice, like the bile, is alkaline and when the chyme ceases to be acid the work of gastric juice stops and that of pancreatic juice begins. The pancreatic gland which nestles in the first lobe of the small intestine and which the butcher may call the "stomach sweetbread" has other parts to play. A part of it functions as a gland of internal secretion or endocrine gland and from specialized nests of cells called *Islets* of *Langerhans,* comes a *hormone,* without which the liver is unable to store glycogen, and the tissues of the body are unable to utilize sugar. The absence or deficiency of this endocrine secretion produces that human disorder known as diabetes mellitus. Diabetic patients must take insulin in order to survive. When blood sugar cannot be utilized by the tissues, it increases in the blood and must be voided in the urine.

Intestinal Secretions

There are yet other enzymes working on the food material as it is conducted along the course of the intestine. An intestinal juice called *succus entericus* is secreted by the glands of *Lieberkuhn* present in the walls of both small and large intestine and *Brunner's* glands which occur only in the submucosa of the duodenal area. The secretion from the glands of Lieberkuhn is watery and carries little digestive agent while the secretion from Brunner's glands contains the enzymes *erepsin, invertase, lactase* and *maltase.*

The flow of bile and pancreatic juice is not continuous any more than the flow of gastric juice or the saliva is steady. Neither is secreted into the intestine during fasting but contact of the chyme with the intestinal lining serves as stimulation. Stimulation is by nervous reflex and also the product of hormone activity; the hormone in this instance is known as *secretin* and

when added to the blood when the acid chyme makes contact with the mucous membrane of the intestine, it is carried by the blood stream to the liver and pancreas. Soap solution will also produce stimulation like that set up by acid and consequently when fat foods are split the fatty acids combine with alkali from the bile to form soaps and further strengthen the supply of bile. Nervous stimulation is faster but less effective than the action of the hormone. At the beginning of the flow the bile comes chiefly from the supply stored in the gall bladder but when the reserve has been exhausted, the flow is directly from the liver. Due to the antiseptic qualities of hydrochloric acid in the gastric juice, there is rarely any bacterial action in the stomach but after the acidity is counteracted by bile and pancreatic juice, conditions are favourable for bacterial growth and such growth seems to be entirely normal in all common species.

The Work of Bacteria

The intestinal tract of new-born animals is sterile but it is known that newly-hatched chicks kept on sterile diets will die in two or three weeks. Laboratory animals on fibre-free diets, on the other hand, have been kept on sterile diets for long periods without harm. What stockman has not seen foals eating fresh horse manure and what stockman has stopped to consider the possibility of such instinctive appetite simply reflecting an urgent natural requirement in order to furnish the digestive tract for its normal operations. It is for the herbivorous animals like the ox, horse and sheep that the intestinal bacteria can do the greatest and most necessary service because the digestion of fibre is dependent upon such organisms. There are no enzymes in the tract that can act upon fibre or cellulose; the job is left entirely to the bacteria. Bacteria are most numerous in the back part of the intestinal tract, and one quarter of the faeces may be made up of bacteria.

Certain types of bacteria may have special parts to play. It has been shown, for example, that the presence of lactic acid produced through the action of certain bacteria working on ingested milk, will maintain favourable intestinal conditions by holding some harmful organisms in check and thereby controlling putrefaction in the human intestine. Lactose or milk sugar is particularly favourable to the development of helpful bacteria such as *Bacillus acidophilus*. Not many years back, the world received the opinion of one *Metchnikoff* of the Pasteur Institute in Paris that the unusual age attained by Bulgarian peasants was due to the consumption of sour milk from goats and the resultant growth in the intestine of friendly bacteria like *Bacillus bulgaricus*.

Bacteria in the rumen of the ox and sheep have recently been credited with new and important responsibilities; they have the power to synthesize certain vitamins needed by the animal and also to build up complete proteins which the animal can later use, from urea or other immature nitrogenous bodies.

Absorption

Absorption is one of the chief functions of the intestine. There is no absorption from the stomach. To increase absorptive capacity, the inner surface of the small intestine is equipped with numerous, small, finger-like projections called villi which increase surface area perhaps by as much as ten times. Close examination of the intestinal wall will reveal a net-work of small blood vessels; the smallest of the vessels, called *capillaries*, are microscopic and these make close contact with the lining surfaces so that digested food can be picked up readily. The blood vessels of the gut converge upon the portal vein and deliver all the digested food to the liver.

Water is absorbed comparatively quickly and the intestinal contents become drier as they pass along.

The carnivorous animals have the shortest tracts; meat digestion is a simple matter compared to fibre digestion. The small intestine of the ox is 125 feet in length, that of the sheep 80 feet; of the horse, 70 feet; and of the pig, 65 feet. In the human, the small intestine is 20 feet. The large intestine of the ox is about 35 feet in length; of the horse, 25 feet; and of the pig, 15 feet.

Intestinal Movements

The intestinal contents are conducted along their course by travelling, ring-like contractions going by the high-sounding name of *peristalsis*. It is as if one were to contract one's fingers about a tube of tooth-paste and move the hand along pushing the contents out of the tube. The stimulation of peristalsis will produce purging and, sluggish peristalsis may be the cause of constipation. Peristaltic waves are of two kinds and in each case there is a marked constriction preceded by dilation of the organ; in one action the wave progresses slowly, perhaps half to one centimeter per minute; this is the main force in the movement of food; the other type, called peristaltic rush, is a speedy type, and seems to have as its purpose the hasty movement of irritating substances. The presence of food in the gut is one cause of peristalsis but there is also a nervous stimulation.

Some cathartics are effective by stimulating and accelerating peristalsis, while others of the saline group accomplish their purpose by increasing the fluidity of the contents through osmosis. Rhythmic contractions are a non-progressive type

whose purpose is simply to break up the ingesta and expose more of it to the digestive agents and the intestinal walls.

The large intestine of the horse is equipped with a large caecum having a capacity of about 8 gallons. This must compensate in part at least for the small stomach of the animal. If the horse was once a carnivorous or omnivorous animal it would seem that the caecum has been enlarged to meet a new requirement. Feed reaches the caecum of the horse about 24 hours after being eaten and is likely to remain there for another 24 hours during which time bacteria attack the fibre; hence there is more absorption in the large intestine of the horse than in the large intestine of the ruminant. There is not much secretion of juices in the large intestine except for mucous although there is nothing to prevent the continued action of enzymes which pass into the large bowel with the ingesta. Bacterial attack may continue in the colon, cellulose being the chief object of that attack. A certain degree of bacterial action on the proteins in the colon may be normal and excessive putrefaction there will probably be held in check in herbivora by the organic acids arising from carbohydrate fermentation.

Food is likely to pass completely through the body of the cow in between 3½ to 4 days and through the pig in roughly 1½ days. In the case of the human, the food material is likely to leave the stomach and enter the intestine in less than 6 hours after it is consumed and 24 hours after being consumed it is likely to be approaching the rectum. But movement of food in farm animals is not always regular. In the ruminant stomach particularly, the food material is mixed and distributed in a marked way; some may pass from the rumen in a few hours and some be there for days. Portions of a meal given to sheep as an experiment were found to pass completely through the body in 24 hours while it was two weeks before other portions passed through.

Cutting a good stand of hay

CHAPTER XXXVI

DIGESTION TRIALS AND NUTRITION BALANCES

Until it was known precisely what the animal did with its feed, exact rationing was not possible. To obtain the needed information, "balance trials" of one kind or another have been employed. They have been in the nature of ledgers with the feed receipts or items of intake on one side and the output or expenditure on the other.

The digestion trial which is intended to show how much an animal can get out of a feed, is the simplest of those undertakings; not all of the constituents in feed consumed are digested and used by the animal and in the trial designed to produce accurate data the protein, carbohydrate and fat of the given feed as determined by analysis would have to be known; then the total intake of each of these would be set down on one side of the "physiological balance sheet", while the total protein, carbohydrate and fat in the faeces for the period of the experiment, placed on the other side. The difference would indicate the amount of each of those constituents digested and retained in the body. The absorption of minerals is not usually considered in these trials.

Digestion Trial

By way of example, a cow on digestion test for 10 days received no other feed than brome hay, and consumed 200 pounds which, according to analysis, contained 4 pounds of fat, 59 pounds of fibre, 85 pounds of nitrogen-free extract and 20 pounds of crude protein. The faeces voided in the same test period contained 2.4 pounds of fat, 24.6 pounds of fibre, 21 pounds of nitrogen-free extract and 8 pounds of crude protein. The digestibility of that brome hay would therefore be shown thus:

	Fat	*Carbohydrates*		*Crude*
		Fibre	*N.F.E.*	*Protein*
Constituents in 200 pounds hay consumed in ten days	4 lb.	59 lb.	85 lb.	20 lb.
Constituents in faeces voided in corresponding period	2.4	24.6	21	8
Difference, indicating amounts digested	1.6	34.4	64	12
Percent digested (Co-efficients of digestibility)	40%	58.3%	75.3%	60%

The passage of food material through the body requires considerable time, nearly four days in the case of the cow and about a day and a half in the case of the pig, therefore it is not an easy task to know exactly when to start and when to stop the gathering of the trial faeces. Two methods are employed; one, which is used in the case of carnivorous and omnivorous animals, consists of employing a "marker" such as lampblack, or iron oxide or carmine. A dose of one of those indigestible products would be given at the beginning of the digestibility trial and another at the conclusion and the appearance of the "markers" in the faeces would indicate the beginning and the last of the faeces to be recovered for weighing and analyzing. But such a method is not satisfactory in horses, cattle or sheep, animals in which the food material is subject to greater mixing when in the alimentary canal. For such animals it is better to extend the period of the test, feeding exactly the same amount each day and gathering the faeces for the number of days which would correspond to the period of experimental feeding. In such cases, the test animals should be on test rations several days before the beginning of the actual trial so that the stomach and intestines would be rid of any other feed materials. In a simple digestion trial, the urine need not be collected.

There are certain uncontrollable factors which may detract from the mathematical accuracy of a digestion trial. One is the conversion of certain portions of feed to intestinal gases which are lost. Then too, there is a certain residue of bile and digestive juices which remains in the faeces and will be analyzed with them.

The cow can be fed on brome hay or other similar roughage alone, or a pig can be given barley or similar concentrate alone and consequently, digestibility trials involving such single feeds for one particular class of animals are comparatively simple. But barley grain can't be fed as the sole item of diet to a cow, nor can molasses be fed to a sheep or tankage to a pig to form the entire ration. Consequently, if these products are to be tested for digestibility, they must be fed in conjunction with feeds, the digestibility of which is already established.

Digestibility is influenced by many factors, as most people know. In the first place, there is a species difference; a cow and a pig do not digest their feed alike and, indeed, their natural diets are very different because the former can digest fibre to the extent of 50% or more while the latter can scarcely exceed 2% or 3%. The presence of fibre makes the digestion of all the constituents more difficult because in coarse feeds, the other constituents which normally are more easily broken down, are

locked within the fibrous cells and are therefore inaccessible to the digestive agents until the cells are ruptured or broken down. Horses, cattle and sheep use fibrous feeds well but nevertheless, the coefficient of digestibility is low in these animals compared to that found in meat eating animals on a natural diet. With dogs on all-meat diets, there is very little intestinal excreta.

Grinding or other processing by mechanical means may avoid waste and permit mixing of feeds, but where stock masticate their feed thoroughly and without waste, there is no digestive advantage in grinding. Most Canadian grains are small and hard and may easily escape mastication; they should therefore be ground for pigs, and cattle and horses. Sheep if their teeth are good, are efficient grinders. The grinding of roughage to a fine state is of doubtful value, and digestibility in cattle and sheep may be actually lowered by it, perhaps through reduced rumination or interference with natural functions. At any rate, cattle fed on finely ground roughage neglect their "cud-chewing". Potatoes and beans, if cooked, will be digested more completely by pigs, but otherwise cooking is not considered an advantage.

Stacking alfalfa hay

Effect of Balance on Digestibility

The thoroughness of digestibility is influenced by balance in rations. A balanced ration according to modern concept is one which supplies feed nutrients of all the essential kinds and in amounts adequate for the physiological work to be performed. Digestion of all the constituents is more complete when the protein level is not too low or when the nutritive ratio is optimum.

If a protein supplement is added to a ration low in that constituent, the result will be more complete use of the carbohydrates and fats as well as better protein nutrition; the increase in metabolizable energy would be greater than that supplied by the extra protein. And now we know that the animal's ability to use many ingredients of the feed, minerals and vitamins included, depends upon the quantitative relationship of one to the others.

The rate at which feed material passes through the tract is a factor affecting digestibility. Rapid passage through the intestines, such as occurs when animals are on heavy rations will reduce the extent of both digestion and absorption, and this is probably why pigs and steers which are fed from self feeders do not make the most economical gains in point of feed consumption. Self feeder stock will make rapid gains but feed consumption per unit of gain will often be 10% or 15% higher than where hand feeding is practised.

Total Digestible Nutrients

The term "total digestible nutrients" has been used in measuring and appraising feed values; it is based upon the heat or energy value of the digestible constituents. The total digestible nutrient value of a feed is determined by adding the pounds of digestible carbohydrates, and the pounds of digestible protein; then to the sum add the figure obtained by multiplying the pounds of digestible fat by 2.25. The digestible fat is multiplied by 2.25 because the heat value of fat is 2¼ times as high as a corresponding unit of carbohydrate material. The total digestible nutrient (T.D.N.) figure for barley is 77.2, for oats 66.2, for wheat bran 58.8, for corn silage 15.0, and for blue grass hay 50.5.

Nutritive Ratio

A balanced ration presupposes correct amounts of all the feed constituents including the essential minerals and vitamins, but the ratio which exists between the protein or "flesh forming" part of the feed and the combination of carbohydrate and fat, is taken as an indication of an important aspect of balance. Again the high energy value of fat must be recognized and, in computing the nutritive ratio, the figure for digestible carbohydrates is added to that for digestible fats multiplied by 2.25, and the total divided by the digestible crude protein. The result would be the second figure of the ratio; the nutritive ratio of barley is 1:7.5, for oats 1:5.5, of wheat bran 1:3.7, of corn silage 1:12.6 and of blue grass hay 1:9.5. These figures show that wheat bran and oats have a higher proportion of protein

than barley, and that blue grass has a narrower nutritive ratio and therefore a higher proportion of protein than corn silage. Generally, when the ratio is wider than 1:6, it is considered to be wide. A wide ratio is a criticism of many common feeds; such feeds would not provide all the protein material required by quick growing young animals or animals in heavy production. The best ratio for one class of animals is not necessarily the best for another; for example, a ratio of 1:5 may be best for a growing pig, while 1:6.5 would be most appropriate for a fattening pig, and 1:8 for a fattening steer.

Other Balance Trials

The digestion trial based upon an exact knowledge of the carbohydrates, fats and proteins present in both feed and faeces, represents the simplest form of balance and is capable of providing useful information about feed materials which the animal organism is removing from the feed as it is passed through the tract, but it does not tell how the respective constituents in the body proper are being used. It does not tell which of the constituents are being burned in the metabolic processes; it doesn't tell if there is a net loss or gain in protein; it doesn't tell if there is positive or negative balance of mineral substances like calcium and phosphorus; it doesn't tell if fat is being stored or burned and it doesn't tell if the animal is losing or gaining in weight. The ordinary weigh-scales will indicate if an animal is gaining or losing in weight but will not show the nature of either gain or loss. In setting up metabolic balance sheets, comparisons must be based on those elements or constituents that are common to both intake and output; they might be based upon "energy" or "carbon" or "nitrogen".

A "nitrogen balance" is conducted like a digestion trial except that the urine as well as the faeces is collected, and will show if an animal is gaining or losing protein. If the nitrogen in the feed exceeds the nitrogen in faeces and urine, it is apparent that the animal is storing that element in the form of protein, while if the nitrogen in faeces and urine is greater than that in the feed, the animal must be losing body protein. A balance for calcium or phosphorus or any other mineral substance could be conducted in the same way.

Balance trials involving gaseous exchange are more complicated. Some of the carbon from the body is eliminated in the form of carbon dioxide in the exhaled air and therefore to do a carbon balance or any form of respiration trial, the experimental animal must be placed in a properly equipped compartment called a respiration chamber. All digested feed materials yield their energy by being oxidized in the body so that a knowledge of the

amount of oxygen consumed and carbon dioxide released in the burning process would be an indication of the extent and nature of the action. The amount of oxygen used in burning must be the difference between the oxygen in the inspired air and that in the expired air. But the amount of heat or energy resulting from the use of a definite amount of oxygen must depend on whether it is carbohydrate material, protein or fat that is being oxidized; when carbohydrates alone are oxidized, the volume of carbon dioxide given off is the same as the volume of oxygen consumed ($C_6H_{12}O_6+6O_2 \rightarrow 6CO_2+6H_2O$ or $\frac{6CO_2}{6O_2}$) because equimolecular quantities of gases occupy equal volumes provided temperature and pressure are the same. Thus the respiratory quotient would be 1. Fat molecules do not contain as much oxygen to team up with hydrogen and therefore part of the oxygen intake, if fat is being burned, appears as water; and consequently the CO_2 exhaled would be less in proportion to oxygen consumed and the respiratory quotient would be less than one or about .7. In the case of protein the quotient is about .8.

By the use of a respiratory chamber the respiratory quotient can be determined and some lead gained as to the kind of product being burned in the body. The nearer the respiratory quotient is to "one", the higher is the proportion of carbohydrates being used, while a quotient close to 0.7 would indicate that fat was the principal item of consumption.

The carbon balance considered in conjunction with the nitrogen balance is capable of showing the extent of gain or loss of fat. Knowing the amount of protein that underwent metabolism, either plus or minus, the quantity of carbon that would be involved in that protein can be determined and the remaining part of the carbon or nonprotein carbon must have been in connection with body fat or carbohydrate.

Calories and Energy Values

Folk may shrink at the name "Calorie" but it holds nothing to frighten one. Actually it could be standard equipment in the vocabulary of the live-stock man and find use in much the same way as such other quantitative terms as inch, bushel, pound, mile and acre. The Calorie is simply a unit by which the heat value or energy value of a feed or a fuel can be measured. A small calorie is that amount of heat necessary to raise the temperature of one gram of water, one degree centigrade. A kilocalorie or large Calorie for which the symbol "C" is used, is the amount of heat required to raise 1,000 grams of water one degree centigrade or roughly, one pound of water four degrees Fahren-

heit. A large Calorie is therefore the equivalent of 1,000 small calories and is the unit which is used most commonly.

How is the heat value or energy value or caloric value of a feed measured? It is accomplished by burning a known quantity of the feed in a bomb calorimeter. The bomb calorimeter is a piece of laboratory apparatus consisting of a double walled chamber, well insulated; the material to be burned is placed in the inner compartment and a known quantity of water fills the surrounding chamber. The food material is ignited by electricity and the heat transferred to the water can be determined readily by the increasing temperature.

Burned in pure oxygen, as in a bomb calorimeter, one pound of pure fat yields 4,222 kilocalories; one pound of carbohydrate material gives off 1,861 kilocalories and one pound of protein, 2,633 kilocalories. A unit of carbohydrate or fat burned in the body gives precisely the same energy or number of Calories as when burned in a calorimeter or in a crucible or in a stove. With protein it is a little different because that constituent is not completely burned in the body and therefore does not yield all of its energy; urea which is excreted in the urine is a by-product which is capable of further burning outside of the body. Hence the fuel value of protein to the animal is slightly lower than the calorimeter calculations would indicate. Instead of being worth 5.8 kilocalories per gram, as shown by the calorimeter, protein oxidized in the body yields about 4.1 kilocalories per gram, net, or approximately the same as the carbohydrate yield.

If the analysis of a feed is known, the gross energy, i.e. the heat produced when the product is burned in pure oxygen, can be determined easily by multiplying the amount of each constituent, carbohydrate, protein and fat, by its heat value. A hundred pounds of corn contained 4.6 pounds of fat, 70 pounds of carbohydrates and 10 pounds of protein and would therefore have a gross energy value of:

$$\begin{aligned} 4.6 \times 4222 &= 19{,}421 \\ 70.0 \times 1861 &= 130{,}270 \\ 10.0 \times 2633 &= 26{,}330 \\ \hline &\ 176{,}021 \textit{ kilocalories} \end{aligned}$$

But feed consumed by the animal is not completely digested and furthermore, in the case of protein, all that is digested is not capable of complete oxidation or burning. "Available energy", or metabolizable energy therefore, would be determined by making three deductions from the gross energy of a feed, namely, energy lost in the undigested portion passed out in faeces, energy lost as urea and energy lost in the form of combustible intestinal

gases. Carbohydrate fermentation in the intestine may account for a loss of 8% of that constituent in the form of gas, mostly methane.

Respiration Calorimeter

Large calorimeters, large enough to accommodate live animals or humans, have been constructed and employed for studying the exact manner in which the food materials are used in the bodies of the experimental subjects. Such are known as respiration calorimeters and are equipped to measure everything entering and leaving the body, solids, gases, and heat production. Balance studies by means of the respiration calorimeter, known as "direct calorimetry", have served to explain many questions about the utilization of feeds and to make possible the establish-

Palomino stallion, Denver

ment of "net energy" values for feeds. In setting up "net energy" values, not only are losses in faeces, intestinal gases and urine deducted from the gross energy but also the energy costs of such processes as mastication, digestion and assimilation. The net energy of a feed would therefore be indicative of the portion which would be available for constructive purposes such as growth, work, fattening, milk production, etc. It was Armsby of Pennsylvania who did the great pioneer work on this continent in measuring animal requirements as well as feed values in terms of net energy.

By means of the respiration calorimeter, the total consumption of energy by the animal can be established and the number of Calories required per day to ensure maintenance can be determined. *Basal metabolism* refers to the minimum energy expressed as Calories which would maintain a resting, non-producing animal without loss or gain in weight.

Young animals require more feed per pound of body weight than do mature stock. Working and producing animals would obviously need more than the idle or non-producers. A man of average size, at rest, requires just under 2,000 Calories per day to maintain his body; a man doing medium work needs 3,000 Calories while a lumberjack at heavy work requires 5,000 or 6,000 Calories daily. Perhaps that will explain why fat pork has long been a popular article of diet in "the bush".

An adequate ration for man or animal, therefore, must provide some bulk and enough digestible feed to ensure sufficient fuel for heat and energy, protein to provide for construction and repair of muscular tissue and a certain intake of minerals and vitamins. Assuming that the mineral and vitamin requirements were being met, the animal's other needs could be pretty well stated in terms of protein and total Calories or therms. The *Armsby Feeding Standard* defined requirements in that manner but the majority of the well-known standards adopted other units such as "starch equivalent", "total digestible nutrients" and "Canadian Feed Units" in stating energy requirements, although these too could be reduced to terms of Calories or kilocalories.

CHAPTER XXXVII

FEEDING STANDARDS

Men of science have sought to define accurately the feed requirements of the various farm animals and to find reliable methods by which to measure feeding values and make comparisons. It is not sufficient to express feed requirements in terms of gallons or even pounds when feed stuffs vary so widely in physical and chemical characteristics. Feeding standards are tables which purport to state feed requirements in specific and exact terms; they represent an attempt at scientific rationing. But feeding standards have definite limitations as well as uses and in feeding practice they must be regarded as approximate guides only.

Thair. Modern feeding standards are the product of evolutionary advancement extending for well over a century. All the early standards came from German workers and were based on simple feeding trials. The German scientist *Thair* in 1810 proposed a plan for feed comparison using a quantity of meadow hay as a unit. In evaluating a named feed, he would state the number of pounds of that feed which would be equal to 100 pounds of hay. It was obviously faulty but it was a beginning.

Grouven. Analytical methods furnished a new and better means of comparing feeds and prescribing for animals. *Grouven* in 1859 propounded a standard based on crude protein, crude carbohydrates and crude fat. It was a big step forward but it took no account of the fact that the constituents in some feeds are more completely digested than in others.

Wolff. Digestion trials cast a new light upon "scientific rationing". *Wolff* offered a new standard in 1864 based on digestible constituents, protein, fat and carbohydrates. For a 1,000-pound cow in milk, Wolff would provide 24.5 pounds of dry matter, with 2.5 pounds digestible crude protein, 12.5 pounds of digestible carbohydrates and 0.4 pounds of digestible fat. Wolff managed to find reliable units and the nutritive ratio which was then recommended, about 1:5.4 was in line with the best advice of

the present day. But Wolff failed to recognize the widely varying needs of milking cows on account of yield and quality of milk given.

Wolff-Lehmann. Lehmann, like his predecessors in the study of feeding standards, was a German. He proposed some major changes in the Wolff standard in 1896. He would adapt the amounts of feed constituents to the quantity of milk a cow gave but still he failed to recognize that 5% butterfat milk is more costly in feed nutrients than 3.5% milk. His tables became known as the Wolff-Lehmann Standard and were used widely in Europe and North America.

Scandinavian Feed Unit. While feeding standards were following a well defined and technical course under the direction of German scientists, a much different and greatly simplified standard was taking shape in Denmark, Sweden and Norway. In 1884, *Prof. Fjord* of Denmark proposed the tables which were to become known as the Scandinavian Feed Unit system. For their basis, the tables had numerous co-operative feeding trials in those Scandinavian countries. Here was a standard with a great advantage in simplicity; it was a one-factor standard and the unit chosen was the equivalent of one kilogram of a standard grain like barley. Wheat, corn and rye were also given the value of 1.0. But because it would take 1.1 kilograms of bran, 1.1 of oats, 2 of alfalfa hay or 6 of skim milk to be equal in feeding value to one kilogram of barley according to the experiments, these latter four feeds were given feed unit values of 1.1, 1.1, 2., and 6. respectively.

In setting down requirements for milking cows, for example, Fjord specified one Feed Unit for every 150 pounds of the cow's live weight, and one additional unit for every three pounds of milk made daily. That might be right and adequate in supplying the needed energy, but it overlooked the essential nature of protein in supporting certain forms of production.

It is confusing that the lower feeding values are expressed by higher figures. But that is not the chief criticism; notwithstanding the great advantages in simplicity, it is now agreed that no system attempting to express feed values by a single figure can be satisfactory. Protein in the feeds and protein requirements of the animals must be given separate consideration.

Kellner and the Starch Equivalent System. Germany's Kellner took another course. He used a respiration apparatus and conducted feed studies which were more thorough than any performed previously. In studying the use of feed by the animal,

he considered digestibility, losses as intestinal gases, losses as urea and energy expenditure on account of digestion; he was thus able to eliminate some of the earlier errors. He gave the feeds he studied a value in terms of pure starch or its equivalent.

He observed that 100 pounds of starch fed to a steer produced 25 pounds of fat; 100 pounds of oats made 15 pounds of fat, that is, 100 pounds of oats produced the same as 60 pounds of starch. The starch equivalent of oats therefore was determined thus

$$\frac{15}{25} \times \frac{100}{1} = 60$$

Kellner set up formulae by which he could estimate the fat producing power of a feed and thus its starch equivalent, from the known amounts of digestible constituents. He would multiply the digestible carbohydrates by .25, the digestible fat by .525 and the digestible protein by .235 and add the result. But there was a discrepancy between his estimated fat production and actual production by tests made, and that discrepancy was related to the fibre content. It became necessary, therefore, to introduce a correction factor which he called a "value number" and finally he would multiply the corrected value for fat produced by four to give the starch equivalent of the feed in question. It was from his work that British scientists adapted their Starch Equivalent System.

In establishing net energy values and expressing results in terms of starch, Kellner was not unmindful of the animals' need for more than energy or calories; his recommendations embodied starch equivalent and digestible protein, both expressed in pounds. In the Starch Equivalent System used in Britain today, a 1,000 pound cow would require 6.35 pounds of starch equivalent and 0.6 pound of digestible protein for maintenance, and for each gallon of average milk (3.7% fat) produced daily, she would need additional 2.5 pounds of starch equivalent and 0.6 pounds of digestible protein.

Armsby. Kellner used the respiration apparatus but *Dr. H. P. Armsby* of Pennsylvania went farther and conducted work with a respiration calorimeter. Thus Armsby was able to do fundamental studies and determine the energy costs of mastication, digestion and assimilation as well as losses from the body and heat losses. He established net energy values for feeds, and prescribed for farm animals by stating the therms of net energy and the digestible true protein needed. Using the 1,000-pound milking cow as an example again, Armsby would recommend 6 therms of net energy and 0.55 pounds of digestible protein to meet maintenance, and for every pound of 4% milk produced

daily, he would make addition of .27 therms of net energy and 0.054 pounds of digestible protein.

Armsby pointed out that one pound of starch equivalent, which was Kellner's unit, had a net energy value of 1.071 therms and thus starch values could be converted to therms and vice versa.

Armsby was on "solid ground" and his standard should have been accepted and used more widely. He gave net energy values to the feeds he studied and these represented a valuable basis for comparisons; to wheat he gave the value 91.82 therms; oats 67.56 therms, barley 89.94 therms; beet molasses 57.10 therms and wheat straw 7.22 therms.

Haecker. Professor *Haecker* of Minnesota offered a Feeding Standard in which requirements were stated as total digestible nutrients and digestible crude protein. He differentiated between feed requirements for maintenance and that for production, and he was one of the first to recognize that the feed cost in producing milk with high fat test is greater than for low test or average milk. He advocated feeding dairy cows according to both quantity and quality of milk, and his recommendations embraced lower and rather more economical levels of protein than had been recommended by Wolff and other German workers.

Savage. Savage of the Cornell Experiment Station recommended higher levels of protein in cow rations. For cows in milk he contended that the nutritive ratio should not be wider than 1:6.

Morrison. The Morrison standards, formerly known as the *Modified Wolff-Lehmann Standards,* were presented in 1915. They are the work of *F. B. Morrison* and have been accepted most widely on this continent. Compared with the old Wolff-Lehmann standards, the Morrison tables were somewhat more saving on protein.

Formerly, the Morrison Standards showed the requirements of the various animals as dry matter, digestible crude protein and total digestible nutrients, per 1,000 pounds of live weight. A range showing the minimum and maximum amounts of each ingredient was provided. In the revised Morrison tables, however, animal requirements are expressed in terms of dry matter (except in the case of cows), digestible protein and the energy part is expressed as total digestible nutrients and also as therms of net energy. In using the table either total digestible nutrients can be used or net energy. In stating amounts of ingredients or energy, the present-day tables state minimum levels and also recommended levels.

The following figures are taken from the extensive Morrison tables to illustrate the methods of making recommendations.

	Pounds of Digestible Protein		*Pounds total Digestible Nutrients*		*Therms of Net Energy*	
	Minimum Advised	*Recommended for good cows*	*Minimum Advised*	*Recommended for good cows*	*Minimum Advised*	*Recommended for good cows*
For Maintenance (per head daily)						
800 pound cow...	0.494	0.536	5.77	6.53	4.62	5.22
1000 pound cow...	0.600	0.650	7.00	7 93	5 60	6 34
1200 pound cow. .	0.703	0 762	8 20	9 29	6.56	7 43
1400 pound cow .	0 805	0.872	9 39	10 63	7.51	8 50
For Production (per lb. of milk)						
3% milk	0 036	0.043	0.261	0 276	0.243	0 257
3.5% milk......	0.038	0.046	0 284	0 300	0 264	0 279
4.0% milk......	0 041	0.049	0.307	0 324	0.286	0.301
4.5% milk	0.044	0.052	0 330	0 349	0 307	0 325
5.0% milk.	0.046	0.056	0.353	0 373	0 328	0.347

Canadian Feed Unit System. This standard was the product of an effort by MacEwan and Ewen to evolve a feeding guide which would combine the best features of the Kellner and British Starch Equivalent Systems, with a good measure of simplicity and usability. Following the Kellner formula, the starch equivalents of the common Canadian feeds were determined and one pound of Western milling wheat of average analysis and a starch equivalent of 73.3, was given a unit value of "one". Unit values given to other feeds were in relation to net feeding value or starch equivalent value; barley earned a value of 1.0; oats of 0.84; cane molasses of 0.7; skim milk of 0.12 and wheat straw of 0.19.

The principle of estimating feed values or animal requirements by a single factor such as Feed Units, Therms or Total Digestible Nutrients is obviously unsound. The energy values or energy requirements can be expressed that way but because of the essential importance of protein, it is necessary to give it individual attention. In the Canadian Feed Unit tables, and Feed Unit values, the energy value of the protein in the feed is included in the total net energy expressed as Feed Units; but the minimum amounts of protein required are also expressed in the tables.

This standard states, for example, that a 1,000-pound cow requires for maintenance, between 20 and 30 pounds of dry matter and 8.2 Canadian Feed Units *containing* 0.6 pounds of digest-

ible crude protein. For each pound of milk having 4% fat, there should be added to maintenance, 0.34 Canadian Feed Units *containing* 0.05 pounds of digestible crude protein.

The need for better rationing on Canadian farms is very apparent, yet economy and efficiency are not to be overlooked. The Canadian Feed Unit System was devised with the hope that it might improve animal feeding in a sound and practical way. Protein levels are higher than those in general use but scarcely as high as in many former standards. In the light of many experiments they would seem to meet the needs of Canadian producers.

Making Use of Feeding Standards

The Feeding Standards provide patterns against which proposed or trial rations may be placed to test approximate suitability. In using the standards a feeder would first compute the requirements of the animal or animals in question and then determine how closely the proposed or actual ration resembled the standard pattern.

Example. A cow weighing 1,100 pounds, giving 50 pounds of 3.5% milk daily, may be used as an example. The ration as proposed consists of 6 pounds of alfalfa hay, 15 pounds of brome hay, 8 pounds of oats and 2 pounds of barley. According to the Canadian Feed Unit tables, this cow's needs may be expressed as follows:

Dry matter for 1100 lb. cow,—22 to 33 pounds daily.

For maintenance.	9.02 C.F.U.	containing	0 66 lb. D.C.P.
For 50 lb. of 3 5% milk	15.25 C.F.U.	containing	2 25 lb. D.C.P.
	24.27 C.F.U.	containing	2 91 lb. D.C.P.

An examination of the suggested ration shows it to be constituted as follows:

6 lb. alfalfa.	5 48 lb. dry matter	3.12 C.F.U.	containing	.690 lb. D.C.P.
15 lb. brome.	13.79 lb. dry matter	8.40 C.F.U.	containing	.825 lb. D.C.P.
8 lb. oats	7 18 lb. dry matter	6.72 C.F.U.	containing	.808 lb. D.C.P.
2 lb. barley.	1 79 lb. dry matter	2.00 C.F.U.	containing	.182 lb. D.C.P.
	28.24 lb. dry matter	20.24 C.F.U.	containing	2.505 lb. D.C.P.

It is now clear that the ration proposed is too low in both C.F.U. value and protein. To bring the ration more closely in line with the standard requirements, and employing the same feeds, the alfalfa could be increased at the expense of the brome and the quantity of grain increased through the barley to bring the Feed Unit value up. The remodeled ration would then appear as follows:

12 lb. alfalfa hay.........	10.96 lb. dry matter	6.24 C.F.U. containing	1 380 lb. D.C.P.
10 lb. brome hay........	9.19 lb dry matter	5.60 C.F.U. containing	.550 lb. D.C.P.
8 lb. oats...............	7.18 lb. dry matter	6.72 C.F.U. containing	.808 lb. D.C.P
5 lb. barley.............	4.45 lb. dry matter	5.00 C.F.U. containing	.455 lb. D.C.P.
	31.78 lb. dry matter	23.56 C.F.U. containing	3.193 lb. D.C.P.

Still the ration is not a perfect fit. It is satisfactory for dry matter, very close to the standard for Feed Unit value, and a little higher than standard for digestible crude protein. Further minor adjustments could be made in the feeds to bring the ration more completely into line with standard, but enough has been done to demonstrate technique.

If the same feeding problem is examined with the aid of the *Morrison Standard*, methods followed would be roughly the same; it would be essential however, that the Morrison tables for feeds be used along with the Morrison Standards. Standards differ and a ration may satisfy one standard better than another. In making a review of standards, it is well to recall that the Canadian Feed Unit recommendations which were designed to accommodate Canadian conditions, are admittedly somewhat easier to satisfy than some other feeding tables; protein is at slightly lower and more economical levels.

Feeding Standard Limitations. Feeding standards possess a good deal of value if correctly used. They can state requirements for energy, protein and mineral matter in more or less exact terms, and they can furnish a basis for comparing rations and measuring efficiency. But feeding standards have very definite limitations which should be recognized by all those who attempt to use them. The chief limitations may be listed as follows:

(1) Feeding standards do not recognize cost differences and the economic necessity of bringing rations into line with prices on feeds and animal products.

(2) Up to the present, the standards have not been able to provide adequate guidance in meeting vitamin requirements of farm animals.

(3) Feeding standards have failed to meet the special needs of individuals such as cows on extremely high production.

(4) They fail to recognize suitability of certain feeds.

(5) Palatability is not considered.

(6) The standards which seem most nearly adequate are too complicated for practical use.

CANADIAN FEED UNIT REQUIREMENTS FOR LIVE-STOCK

(From Canadian Animal Husbandry, by MacEwan and Ewen)

		Dry Matter in Total Ration	Canadian Feed Units	
Dairy Cattle				
Cows, maintenance per 1,000 lb.		20—30 lb.	8.2	containing 0.6 lb. Digestible Crude Protein.
Per lb. of milk testing 3% add			.27	" 0.04 " " " "
Per lb. of milk testing 4% add			.34	" 0.05 " " " "
Per lb. of milk testing 5% add			.41	" 0.06 " " " "
Growing Heifers, per 1,000 lb. live weight		20—25 lb.	10.91	" 0.80 " " " "
Beef Cattle				
Cows, maintenance	per 1,000 lb. live weight	18—23 lb.	8.20	containing 0.60 lb. " " "
Growing heifers	" " " " "	20—25 "	10.91	" 0.80 " " " "
Fattening calves rising 1 year (for 2 lb. gain per day)	" " " " "	23—27 "	15.83	" 2.00 " " " "
Fattening yearlings rising 2 years (for 2.25 lb. gain per day)	" " " " "	21—25 "	15.14	" 1.60 " " " "
Fattening mature cattle (for 2.5 lb. gain per day)	" " " " "	19—23 "	17.46	" 1.60 " " " "
Sheep				
Ewes in lamb	per 100 lb. live weight	2.2—2.5 lb.	1.36	" 0.12 " " " "
Ewes in milk	" " " " "	2.5—2.7 "	2.00	" 0.24 " " " "
Ewes, 6 to 18 months	" " " " "	2.5—2.7 "	1.77	" 0.22 " " " "
Fattening lambs (for gain of 2 lb. per week)	" " " " "	2.7—2.9 "	2.32	" 0.24 " " " "
Pigs				
Sows in pig	per 100 lb. live weight	1.4—2.0 lb.	1.50	" 0.17 " " " "
Sows in milk	" " " " "	2.2—2.6 "	2.60	" 0.28 " " " "
Pigs 50 to 100 lb.	" " " " "	4.0—4.2 "	4.10	" 0.52 " " " "
Pigs 100 to 150 lb.	" " " " "	3.3—3.7 "	3.75	" 0.42 " " " "
Pigs 150 to 200 lb. (fattening)	" " " " "	3.0—3.3 "	3.34	" 0.36 " " " "
Horses				
Horses idle	per 1,000 lb. live weight	15—18 lb.	7.50	" 0.65 " " " "
Horses at medium work	" " " " "	18—21 "	13.64	" 1.30 " " " "
Horses at heavy work	" " " " "	20—23 "	16.37	" 1.48 " " " "
Mares in milk	" " " " "	18—23 "	13.64	" 1.50 " " " "
Growing colts	" " " " "	18—20 "	13.00	" 1.50 " " " "

Chapter XXXVIII

FINDING PRACTICAL METHODS FOR COMPARING FEED VALUES AND FEED PRICES

There is need for satisfactory methods of measuring and comparing feeds. No one would consider buying feed by the armful and buying by the pound is not always much better unless consideration is given to the exact nature of the product. Feeds vary greatly in constitution; a feed like hay, for example, may contain 90% of dry matter and 10% of water while some other feeds will carry only 10% of dry matter and 90% of water.

Perhaps a pound of dry matter in corn silage is worth a little more than a pound of dry matter in hay but nevertheless, there should be a fairly close relationship in point of costs. A pound of dry matter, although not entirely adequate, would be a much better unit for use in feed negotiations than a pound of gross weight. The stockman who paid one-half cent a pound or $10.00 a ton, for a quantity of mangels for his pigs may represent an extreme case; the fact was, however, that he paid five cents a pound for the dry matter in the roots while he could buy barley and shorts for less than a cent a pound of dry matter.

But a pound of dry matter in one feed does not necessarily have the same feeding value as a pound of dry matter in another; to simply evaluate feeds on the basis of dry matter is not adequate. A pound of dry matter in a feed which is low in fibre and high in protein must be more valuable than a pound of dry matter in wheat straw. A proper evaluation, therefore, should be in line with the composition of the dry matter and digestibility. A feed like slough hay with 0.7% digestible fat, 41% digestible carbohydrates and 3% of digestible crude protein is not as valuable for feeding as prairie hay with 1.3% of digestible fat, 45.1% of digestible carbohydrates and 4.5% of digestible crude protein.

Attempts have been made to attach to each of various feeds a value which can be expressed by a single figure. In the case of the feeds just noted, slough hay and prairie hay, the former could be given a Total Digestible Nutrient value of 45.6 and the latter a value of 52.5. Or the former might be given a Canadian Feed Unit value of .37 per pound and the latter a value of .56.

(The Canadian Feed Unit, explained elsewhere, has for its basis the amount of net energy contained in one pound of Western milling wheat).

The Canadian Feed Unit values for some common feeds are:

Wheat	1.0	Oat Hulls	.47	Brome Hay	0.56
Oats	0.84	Beet Molasses	0.68	Oat straw	0.27
Corn	1.11	Corn Silage	0.17	Wheat Straw	0.19
Wheat Bran	0.6	Potatoes	0.27		

These figures have merit in expressing net energy values or fuel values. They would be useful to indicate fattening and maintenance capacities of these feeds. They could be applied successfully to a range of common feeds which are low in protein and fed mainly to furnish energy or calories, for the purpose of estimating money values. It might be shown for example, that with barley at 48 cents per bushel, the feeder who was considering net energy values or Feed Units, would not wish to pay beyond 29 cents a bushel for oats, $15.60 per ton for recleaned screenings, 60 cents a bushel for wheat or 8 cents a gallon for beet molasses. Employing the same basis of comparison, when prairie hay sells

Horses of western saddle type

at $12.00 per ton, the comparable money value of oat straw should not be above $6.22 a ton and of corn silage not over $3.64 per ton.

But such methods do not recognize the special part that proteins play in the ration; protein-rich feeds like tankage, linseed oil meal, fish meal, etc. should be evaluated on the basis of protein and comparisons restricted to feeds like themselves. It may not be inappropriate to attach money values to a pound or unit of digestible crude protein in such cases. If tankage containing 50% of digestible crude protein can be bought at $50.00 per ton, the cost per pound of digestible crude protein is five cents. Buttermilk containing 3% of digestible crude protein should by the same scale of values for protein be worth 15 cents per 100 pounds. The pig feeder could pay up to 15 cents per 100 pounds of buttermilk as readily as $50.00 per ton for tankage of the quality noted.

Tables shown herewith will illustrate the methods proposed for feed price comparisons.

Comparable Prices on Certain Roughage and Succulent Feeds

(Computed on basis of Canadian Feed Units)

	Oat Hay per ton	*Prairie Hay per ton*	*Oat Straw per ton*	*Wheat Straw per ton*	*Corn Silage per ton*	*Swede Turnips per ton*
Prices comparable to brome hay @ $4 a ton	$4.00	$4.00	$2.07	$1.36	$1.21	$0.80
Prices comparable to brome hay @ $6 a ton	6.00	6.00	3.11	2.04	1.82	1.18
Prices comparable to brome hay @ $8 a ton	8.00	8.00	4.14	2.72	2.42	1.57
Prices comparable to brome hay @ $10 a ton	10.00	10.00	5.18	3.39	3.03	1.96
Prices comparable to brome hay @ $12 a ton	12.00	12.00	6.22	4.07	3.64	2.36
Prices comparable to brome hay @ $14 a ton	14.00	14.00	7.25	4.75	4.24	2.75
Prices comparable to brome hay @ $16 a ton	16.00	16.00	8.29	5.43	4.85	3.15
Prices comparable to brome hay @ $18 a ton	18.00	18.00	9.32	6.10	5.46	3.54
Prices comparable to brome hay @ $20 a ton	20.00	20.00	10.36	6.77	6.07	3.93
Prices comparable to brome hay @ $22 a ton	22.00	22.00	11.39	7.45	6.67	4.32
Prices comparable to brome hay @ $24 a ton	24.00	24.00	12.43	8.14	7.28	4.71

Comparable Prices on Certain Concentrate Feeds
(Computed on basis of Canadian Feed Units)

	Oats per bu. 34 lb.	*Wheat per bu. 60 lb.*	*Recleaned Screenings per ton*	*Corn per bu. 56 lb.*	*Wheat Shorts per ton*	*Beet Molasses per gal.*
Prices comparable to barley @ 20c per bu.	$ .12	$ .25	$6.50	$ .26	$6.75	$ .03
Prices comparable to barley @ 24c per bu.	.14	.30	7.80	.31	8.10	.04
Prices comparable to barley @ 28c per bu.	.17	.35	9.10	.36	9.45	.05
Prices comparable to barley @ 32c per bu.	.19	.40	10.40	.41	10.80	.05
Prices comparable to barley @ 36c per bu.	.21	.45	11.70	.47	12.15	.06
Prices comparable to barley @ 40c per bu.	.24	.50	13.00	.52	13.50	.07
Prices comparable to barley @ 44c per bu.	.26	.55	14.30	.57	14.85	.07
Prices comparable to barley @ 48c per bu.	.29	.60	15.60	.62	16.20	.08
Prices comparable to barley @ 52c per bu.	.31	.65	16.90	.67	17.55	.09
Prices comparable to barley @ 56c per bu.	.34	.70	18.20	.72	18.90	.10
Prices comparable to barley @ 60c per bu.	.36	.75	19.45	.77	20.20	.10
Prices comparable to barley @ 64c per bu.	.38	.80	20.80	.82	21.60	.11
Prices comparable to barley @ 68c per bu.	.40	.85	22.10	.88	22.95	.11
Prices comparable to barley @ 72c per bu.	.42	.90	23.40	.94	24.30	.12
Prices comparable to barley @ 76c per bu.	.44	.95	24.70	.99	25.65	.12
Prices comparable to barley @ 80c per bu.	.46	1.00	26.00	1.04	27.00	.13

Comparable Prices on Certain Protein-Rich Feeds

(Basis of Digestible Crude Protein at Levels Shown)

	Cottonseed oil meal (34% D.C.P.)	*Soybean oil meal* (37% D.C.P.)	*Coconut oil meal* (19% D.C.P.)	*Corn Gluten meal* (31.5% D.C.P.)	*Tankage* (50% D.C.P.)	*Fish Meal* (53.5% D.C.P.)
Prices comparable to linseed oil meal (31.5% D.C.P.) at $25 a ton.	$26.99	$29.38	$15.09	$25.00	$39.70	$42.47
Prices comparable to linseed oil meal at $30 a ton.	32.39	35.25	18.11	30.00	47.64	50.96
Prices comparable to linseed oil meal at $35.00 a ton.	37.78	41.13	21.12	35.00	55.58	59.46
Prices comparable to linseed oil meal at $40 a ton.	43.18	47.00	24.14	40.00	63.52	67.95
Prices comparable to linseed oil meal at $45 a ton	48.57	52.88	27.15	45.00	71.46	76.45
Prices comparable to linseed oil meal at $50 a ton.	53.97	58.75	30.17	50.00	79.40	84.94

It is particularly important to note the limitations and weaknesses in a table such as the above. The comparisons in the last table are based on digestible crude protein only, and take no account of other feed constituents, palatability, quality of protein, etc. The products of animal origin and soybean oil meal would have an advantage in quality of protein while the vegetable products generally would have an additional net value on other counts such as carbohydrates, palatability, etc. It is difficult to assess the healthful and stimulating qualities of linseed oil meal for example, and its true value in relation to other feeds is certain to be greater than that shown by figures given in this or other table. Notwithstanding limitations, such a table can be useful to the person who understands the characteristics of the feeds in question.

Production Costs in Feed Units. A practical "measuring stick" for use in purchasing feeds of one particular kind, might also be helpful in making certain comparisons related to production costs. The tables showing composition and feeding values which appear in connection with Feeding Standards, can be useful.

The Canadian Feed Units or pounds of Total Digestible Nutrients required to produce 100 pounds of milk, or one pound of butterfat, would be more indicative of economy of production than gross weight of feed. One herd studied, was making 100 pounds of milk on 78 C.F.U. and another was doing the same on 60.

Suppose two cows are up for comparison. Feed consumption per unit of production might be compared according to the following:

Cow No. 1 in 30 days produced 1,200 lb. of milk, testing 3.6% fat = 43.2 lb. of butterfat.

Feed consumed in 30 days

600 lb. brome hay	336 C.F.U.
150 lb. barley	150 C.F.U.
200 lb. oats	168 C.F.U.
50 lb. linseed oil meal	50 C.F.U.
	704 C.F.U.

Canadian Feed Units per 100 lb. milk = 59.
Canadian Feed Units per pound of butterfat = 16.3

Cow No. 2 in 30 days produced 1,000 lb. of milk, testing 4% fat = 40 pounds of butterfat.

Feed consumed in 30 days

300 lb. alfalfa hay	156 C.F.U.
300 lb. oat hay	168 C.F.U.
200 lb. barley	200 C.F.U.
100 lb. oats	84 C.F.U.
100 lb. bran	60 C.F.U.
	668 C.F.U.

Canadian Feed Units per 100 lb. milk = 66.8
Canadian Feed Units per pound of butterfat = 16.7

This comparison shows that in Feed Unit cost of producing 100 pounds of milk, the No. 1 cow had the better performance; with butterfat the same cow held the advantage but the difference was comparatively slight.

Protein-Weighted Values for Price Appraisal of Feeds

How far can one go in establishing a basis for price appraisal on feeds of different protein levels when both energy and protein are to be considered? The buyer pays much more for protein than for carbohydrates although there is no fixed relationship or differential between them.

If an average relationship could be worked out, it would serve as an approximate guide in price appraisal for high and low-protein feeds. It would show the approximate money value of bran in relation to barley, or cottonseed meal in relation to oats, for example. A review of Canadian feed markets suggests a simple formula by which a protein-weighted value for use in price appraisal can be worked out for each feed. The formula is

Total Digestible Nutrients + (5.4 × Digestible Crude Protein). Applied to some common feeds, the price appraisal figures (basis 100 lb. feed) would be:

Barley	126.34
Bran	123.60
Linseed Oil Meal (Old Process)	241.72
Cottonseed Oil Meal	256.80
Tankage (50% D.C.P.)	345.00
Alfalfa hay	113.10
Oat hay	83.32

To use these figures in comparing feed prices, they should be converted to prices per unit of weight. If in this instance, barley is priced at $20.00 a ton, comparable prices on the other feeds would be as follows:

Bran	$19.56 per ton
Linseed Oil Meal	38.27 per ton
Cottonseed Oil Meal	40.65 per ton
Tankage	54.61 per ton
Alfalfa hay	17.89 per ton
Oat hay	13.18 per ton

Besides providing a practical method, the above illustrations furnish convincing evidence about the relatively high cost of protein materials secured through the feed trade and the tremendous savings which can come from such home grown feeds as alfalfa hay and other legumes.

CHAPTER XXXIX

PUTTING FEED TO WORK

Feed represents fuel and raw materials with which the animal body can do its work. The principle functions for which feed is needed are as follows:

1. Maintenance
2. Growth
3. Fattening
4. Reproduction
5. Milk
6. Muscular Work
7. Wool

Maintenance

A maintenance ration is one which will support a resting and non-producing animal without loss or gain in weight. Feed to supply energy is the chief need although appreciable amounts of protein and mineral matter are also needed. Energy is required to maintain body temperatures, to support circulation of the blood, respiration and other physiological processes, whether the animal is on maintenance or in production. In the absence of adequate feed, the energy needed to support these functions must come from the breakdown of body tissues; this is called "fasting catabolism" and body fats are first to be used and then protein tissue will suffer.

Energy for maintenance is higher in the big animals than in the small ones but the requirement is not in proportion to the weight. Rather, maintenance requirements bear a close relationship to body surface and a ton of rabbits would require ten times as much energy as a ton of horses. Nevertheless since surface area is difficult to determine and since the farm animals likely to be under comparison are not radically different in size, it is customary to overlook an obvious error and regard weight as a practical basis for estimating maintenance needs.

While the production of energy is the main objective of maintenance rations, it is fair to observe that the energy cost in keeping body warmth up to normal is not as great as it might

at first appear. In the expenditure of energy in doing internal work, heat becomes a by-product; low grade roughages like cereal straws, have more value for winter maintenance than they have in the support of production, because the digestion of such feeds consumes a lot of energy and releases a lot of heat which will help to keep the body at normal temperature. Normal body temperatures in farm animals are all close to 100°F.

Even on protein-free diets, there will be some loss of nitrogen from the body, which testifies to the need for protein in the rations of all animals including those which are non-active. For cows on maintenance, the feeding standard would prescribe 0.6 pounds of digestible crude protein daily per 1,000 pounds live weight. The case of mineral matter in maintenance rations is much the same; it is needed; in fact death can be induced by mineral starvation; but the daily maintenance requirement is small because the body spares its resources effectively when not in production. The iron from broken down haemoglobin for example, is re-utilized in the manufacture of new red blood cells.

Maintenance must be the first charge against the feed in any ration. It is approximately correct that one half of the feed of farm animals goes for maintenance, the remaining half being available for productive purposes.

Growth

The growth of an organism begins at conception. Normal growth progress as indicated by increasing size and weight continues in an uninterrupted manner until maturity. In embryonic life, growth is accomplished by increase in number and size of the cells, and in later life, mainly by increase in size of cells. In either case there is enlargement of muscles, bones and organs, such enlargement reflecting the utilization of protein, calcium, phosphorus and water in substantial amounts, and other minerals and vitamins in smaller amounts.

Goldbar herd of Shorthorns. Owned by Claude Gallinger.

Growth performance of young animals of different species varies a good deal as the following data will show:

Approximate Weights of Young Animals

	Birth Weight	*Birth Weight as percentage of Mature Weight*	*Time Required to Double Birth Weight*	*Weight at One Year in Relation to Birth Weight*
Pig	3 lb.	—	10 days	130 times
Lamb	9 lb.	6%	25 days	15 times
Calf	75 lb.	6%	45 days	9 times
Draught Foal	130 lb.	8%	60 days	6 times
Human Baby	8 lb.	5%	180 days	3 times

So-called "normal growth" for a species, frequently illustrated as a curve, represents an average of growth records for well-fed animals. But growth performance varies greatly, and while hereditary factors influence growth and limit maximum size ultimately, it is a fact that nutrition is the main factor in determining rate of growth. Weight is the most common measure of growth but it is not entirely reliable; animals receiving fattening feeds and insufficient protein may show a weight which exaggerates dimensional size. On the other hand, an animal receiving plenty of bone building material but less of energy-rich and protein-rich feeds than is needed to support good growth, may develop a large, boney framework and a lean and underweight body.

Where growth is retarded temporarily and moderately as a result of feed limitations, the growing period is extended but normal mature size may still be reached. Such animals as have experienced only a minor check on growth will respond quickly and economically to good and adequate feed and make very acceptable candidates for the feed-lot. But when a famine condition or inadequate feeding is prolonged, the animals may become so stunted that normal mature size will never be reached, even when good feeding is resumed.

Disease, parasites and early pregnancy are among the causes of stunted growth in farm animals; but feed lacking sufficient energy, protein or some other feed constituent is the most commonplace reason. The energy needed to support growth can be furnished by carbohydrates and fats and the supply must exceed what is required for maintenance. The protein needed for the enlarging muscles must come from feed protein and since practically all increase except for bone and water, is in protein tissue, it becomes immediately apparent that the protein requirement in growing animals is high. A nutritive ratio of 1:10 is satisfactory for mature horses but 1:7 is better for growing colts. The same principle applies with other classes of farm stock.

Calcium, phosphorus and vitamin D are particularly needed for growth of skeleton. In fast growing animals, calcification or deposit of calcium and phosphorus in the bone tissue is hastened, provided the necessary minerals and vitamin D are adequate. With energy and protein material sufficient for rapid growth, and nutritional conditions for calcification unfavourable, the bones may be normal in size but weakened on account of low ash content or lack of density. Such bones will often develop swellings at the joints or bowing as in rickets. A deficiency of phosphorus may also have the effect of depressing appetite and thus cause reduction in rate of growth. Other feed factors needed for growth are sometimes in short supply, notably vitamin A. The importance of variety as a practical means of assuring the needed materials can scarcely be overstressed.

Young and growing animals will eat more feed per unit of live weight than will mature stock, and will make a unit of increased weight on less feed. Rapid gains in market animals are usually most profitable; if a pig can be brought to 200 pounds in one hundred and sixty days instead of two hundred days, it stands to reason that there will be a smaller feed cost for maintenance and a bigger percentage of feed to support growth.

Fattening

Fattening is simply a matter of promoting the storage of body fat. Animals are fattened mainly to improve the quality of their meat and hence their selling price on the market. Beef, pork and lamb from fattened animals have more juice, more flavour and greater tenderness than meats from thin or underfinished animals. The meat market calls for carcasses which carry an even covering of firm fat. A smooth and even external covering of fat is co-related with marbling and is therefore in keeping with maximum quality. Uneven deposit of fat and patchiness represent wastiness and are not conducive to marbling.

Marbling in meats is identified by tiny traces or deposits of fat, scattered through the muscle tissue. Fat may occur *inter*-cellularly as well as *intra*-cellularly, but the fat which is identified as marbling is an inter-cellular deposit; it may be stated more correctly as a deposit in the inter-fascicular and inter-muscular connective tissue. Marbling is more pronounced in pig muscle than in beef or lamb.

Fat represents a body reserve of energy material and in the case of farm animals, it usually comes from carbohydrates and fats in the feed. It is possible to create body fat from surplus protein but feed protein would be an extravagant source of fat. Fattening rations, therefore, must include generous allowances

above maintenance requirements and must be high in carbohydrate material and comparatively wide in nutritive ratio. With animals which are growing as well as fattening, such as baby beef, more protein is needed; for fattening baby beef a nutritive ratio of 1:7 is suggested while two-year-old steers do well on a 1:8 ratio.

A well finished crossbred steer

Reproduction

Pregnancy creates certain new demands upon feed. They are specific demands and deserve careful study but at the same time the extra burden made by pregnancy is not as costly in energy and protein as is sometimes supposed. The body of the unborn animal is mostly water; the six-months calf foetus is about 85% water and therefore about the same in percentage of solids as cows' milk. The calf at birth is about 70% water and a 75-pound specimen would possess 22½ pounds of dry matter, or about the same weight of solids as would be present in 175 pounds of average milk. The production of foetal membranes represents a feed cost not to be overlooked but when the total feed requirements for the extra protein and energy material required for the making of a calf are spread over a period of nine months, they do not represent a great nutritional burden in comparison with that of lactation.

Stockmen know that pregnant barn-yard females fatten readily and some breeders contend that the in-foal mares will show a better response to feed than other horses. It may be that except for certain specific requirements, rations which will support growth will meet the needs of pregnant females. But what are those specific needs?

Until the embryo has become implanted and equipped with a placenta, it is nourished by secretions from the walls of the uterus and in the larger farm animals like cows and mares, growth is slow during the early months. After the young creature has become enveloped by placental membranes, nourishment is drawn from the mother's blood, by way of the umbilical cord.

Foetal demands upon feed nutrients are very slight in the early stages of pregnancy but they become greater as the foetus matures; protein and calcium and phosphorus become incorporated at an increasing rate. In some ways nature seems to place the well-being of the unborn animal above that of the dam and so far as energy material and protein are concerned, sufficient will be drawn from the mother, even though her feed be inadequate. But an insufficiency of some other feed substances such as iodine or vitamin A, for which there may not be much maternal reserve, may cause prenatal death, weakness or abnormality at birth.

Yorkshire gilts showing good breeding and good feeding

Notwithstanding the observation that only a few pounds of pure protein are present in the body and membranes of a newborn calf, workers agree that protein should be furnished in the rations to pregnant females in excess of maintenance and actual foetal requirements. Protein-rich rations are invigorating and it is most important that some body reserves be created before lactation.

Ewes which have had the benefit of some good legume hay in the months prior to lambing will milk better than those which were on poor rations. The same may be true of the bone building constituents; the foetus may safely draw upon the mother's skeleton up to a point but continued depletion will result in weakness of the offspring at birth and a reduced milk supply for it. The rations to pregnant farm animals therefore, should provide calcium and phosphorus with sufficient vitamin D to meet all needs of the growing foetus and also provide generously for the dam in whose body some reserves may be built.

The essential nature of iodine in the rations of pregnant animals has been clearly demonstrated. The conditions of hairlessness in pigs, goitred lambs and calves, and weakness in new-born foals are attributed to lack of iodine. In iodine deficient areas it is becoming general practice to supply supplemental iodine, especially during winter months. Shortage of iodine may also be a factor contributing to shy breeding in farm animals.

Vitamin A is known to be an essential in normal reproduction and a shortage may relate itself to breeding failure, abortions, weakness or death of the young at birth, retention of afterbirth, scours in the new-born, and other troubles. Vitamin A deficiency is known to be wide-spread in winter feeding practices. But body storage can be good with both vitamins A and D, and there is reason to believe that where these are furnished adequately during pregnancy, a better supply of them will be present in the body of the new-born animal, making it less susceptible to scours, rickets and some other disorders.

Milk Making

The udder is a highly specialized organ for the manufacture of milk. In the case of the cow there are four quarters or glands or unit "factories"; each is supplied abundantly with blood by which the raw materials from the digested feed, are carried.

Percheron stallion, Leroy, Grand Champion at Edmonton, April, 1944

Each quarter of the cow's udder has its teat, with central teat canal and sphincter to prevent loss of milk by leaking. Above the teat canal is the milk cistern, a cavity holding from one-half to one pint. But such storage would be altogether inadequate for heavy milkers unless milk could also be held in the upper reaches of the udder. The fact is that numerous ducts lead away from the cistern; these ducts branch and rebranch and terminate in the alveoli, where milk is made and the flow started.

Studies at the University of Minnesota showed that 400 pounds of blood go through the cow's udder for every pound of milk secreted; it adds up to 10 tons of blood passing through the udder every 24 hours in a cow which produces 50 pounds of milk daily. Quite a few Canadian dairymen have heard *Dr. W. E. Peterson* of that institution explain how the work done in pumping that blood represents the equivalent of loading 10 tons of manure on a wagon 47 inches from the ground. That is the work of pumping the blood through the udder only and takes no account of the supply to other organs of the body or the provision of raw materials which enter into the composition of milk.

Body hormones originating in the ovaries or pituitary gland are the "sparks" which fire the mechanism of milk secretion. The hormone or "chemical messenger" called *estrogen* comes from the ovaries and stimulates the development of the ducts in the udder while *progesterone* from the corpus luteum or yellow-body on the ovary during pregnancy, stimulates development of the secreting cells and alveoli. A third hormone called *prolactin,* originating in the pituitary gland, sets the process of secretion in motion at the time of parturition.

Colostrum. The first milk, called *colostrum,* is quite different from later milk and is adapted especially to the needs of the new-born. It is high in total solids, high in protein (mostly globulin and albumin), high in vitamin A, and laxative. On account of the vitamin A and antibodies present in colostrum, it makes an extremely important contribution to the health of the new-born animal.

Production. In cows, production will reach a peak about a month after the onset of lactation and then there is a gradual decline. If the cow is in calf again at the usual time, the decline in milk flow will become more abrupt at about seven months of lactation.

The materials needed to manufacture milk must come from feed or from the animal's body reserves. It is shortly after freshening when the stimulation to produce milk is greatest, that production is most likely to exceed the levels which would be sup-

ported by the feed. In other words, a cow is more likely to call upon body reserves near the beginning of lactation, and more likely to milk according to feed later in lactation.

Secretion. Contrary to an old view that most of the milk is made at the time of milking, it is now clear that secretion is continuous but at a reduced rate when milk has accumulated sufficiently to set up considerable pressure within the udder. Increasing pressure would ultimately cause secretion to cease. Herein lies the reason for more milk being produced when high yielding cows are milked three or four times a day instead of twice; udder pressure does not become so high and secretion will be at maximum for a larger part of the time.

Nearly all the milk recovered at milking is present in the udder at the time milking is started. The phenomenon known as "letting down the milk", does not represent any sudden increase in secretion but rather a temporary increase in udder pressure, the product of a reflex stimulated by hormones which are released when the contented cow anticipates milking or when the teats and udder are massaged by calf or milker. It has been termed "erection of the udder" and may be due to muscle contraction or retarded flow of venous blood.

In any case, the result of the pressure is to force the milk from the cells and passages towards the cisterns and teats. The pressure passes off shortly and hence fast milking will gain much better advantage from that natural aid and get more milk. Prompt milking after the onset of udder erection is equally important; washing the udder fifteen or twenty minutes before milking reduces the yield and shortens lactation because the natural aid to thorough removal of milk will have passed off before the milking operation is completed.

Raw Materials for Milk. Everything going into the composition of milk comes from the feed and passes to the udder by way of the blood stream. Some of the milk constituents are completely remade in the secreting cells of the udder. Milk fat, milk sugar and the casein are synthesized in the secreting cells from materials brought by the blood; but the mineral matter and part of the protein are drawn directly from the blood. Milk fat is usually reconstituted from fats in the blood therefore a certain amount of fat is considered important in dairy rations. Nevertheless, the average percentage of fat in cows' milk will be practically unchanged, even on fat-free rations. It is known that carbohydrates and perhaps proteins can be used to make milk fat.

Fat is the one constituent of cows' milk which fluctuates widely, even in a single individual, although protein content tends to be greater with higher fat tests. Efforts to control milk fat variations have not been successful. No common feeds have been found which will directly raise the average test, although many have been thought to raise or lower the level. In some extensive trials at the University of Saskatchewan, a study was made with common cereal grains, grain by-products, brewers' wet grains, sunflower silage, low and high protein levels and watering practices, and in no case was there any significant change in butterfat percentage. Cod liver oil is one feed substance which will depress fat test in cows and it is thought unwise to feed much in excess of one ounce a day.

The feed required by lactating animals will exceed maintenance needs to the extent of the constituents in the milk, the physiological costs of performing the work, and wastage. Compared to non-lactating animals, there is in particular a higher

Herd of prize winning Guernseys. Owned by Wm. S. Brooks, Paris, Ont.

expenditure of protein, calcium and phosphorus. The quality or completeness of the protein is import in lactating sows but of less importance in ruminants which are known to possess the power of reconstituting this feed constituent through the medium of bacteria in the paunch.

Salt, calcium and phosphorus are the mineral elements most needed by the lactating females. The calcium and phosphorus content of cows' milk is about 5 grams of the former and 4 grams of the latter per gallon. In sows and ewes the proportion of these is higher. It may be the case with most species that the expenditure of calcium and phosphorus in the milk during the period of heavy milk flow, will exceed replacement in spite of good feeding,

and thus build up a negative balance. Such a minus balance must be made good later in lactation when production is lower or during the dry period to follow. The mineral depletion during lactation can become so great that weakened bones, fractures and other complications, including breeding failures will occur.

Muscular Work

Muscular work represents a direct charge on feeds, and the feed requirements of working horses will exceed maintenance by an amount bearing a direct relationship to the amount of work being done. The total expenditure of energy in a horse doing average field work, would be about 3,000 to 3,200 Calories per hour, compared with 700 Calories for the same horse standing idle.

One big advantage in horses as compared with mechanical power is their adaptability to a wide range of working conditions. A horse can pull a light load at fifteen miles an hour and on a

Six-horse teams at a Canadian exhibition

slow, steady draw it can exert a pressure up to half its own weight. A draught horse is at its best in point of general efficiency exerting a pull equal to 10% of its own weight and travelling at 2½ miles per hour. At higher speeds, efficiency is reduced mainly on account of the unproductive movements of the body and the generation of extra heat which is wasted.

A 1,600 pound horse, pulling 10% of its own weight at 2½ miles per hour would be doing 35,200 foot-pounds of work per

minute which is just a little over the equivalent of one horse power. Continued for ten hours, the work done would represent 10.6 horsepower hours. (One horse power is the power required to lift 33,000 pounds at the rate of one foot per minute, or 33,000 foot-pounds per minute).

Gross efficiency in a working animal is not over 25% but even that figure is well above the best that can be achieved by farm motors. The first call upon the energy material intake of a horse, is for maintenance; then some energy must be spent to take care of the increased activity of the heart and other organs while work is being done. Finally there is some wastage of energy due to non-productive movements.

In accomplishing physical work, the great need is for energy-rich feeds. Horses doing 20 miles of field work a day, or horses doing correspondingly heavy work will lose condition rapidly if the energy needed is not provided in the feed. Rations rich in Feed Units, chiefly carbohydrates, best fit the need. The expenditure of protein in the course of work is correspondingly small. Strangely enough, rations appropriate for working horses are not unlike those suited to fattening animals.

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Date Due

13 '72			
31 '72			
APR 28 '84			
CIRC FE 19 '74			
FEB			
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OCT			
DUE	JAN 31 '81		
TURN			
DUE	84		
NOV			
TURN			